SUBSCRIPTION RATES:

The Annual Subscription, post free, to any part of the world is 21/- (English) or its equivalent in other currency. The price of single copies is 1/6, or 1/9 if sent by post. Back numbers (when available) are charged double if over six months old.

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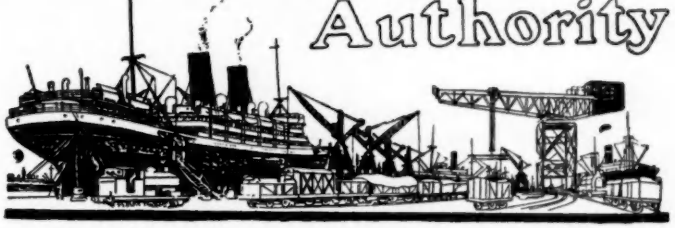

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Editorial Comments

Polish Ports.

It is many years since a descriptive article upon the Port of Gdynia appeared in this Journal, and much has happened in the interval which has elapsed since the port was constructed in 1926. We are therefore glad of the opportunity to print an article by Stanislaw Hückel, upon the three Ports of Gdynia, Gdansk (Danzig) and Szczecin (Stettin), which now all lie within Poland's 300 mile long coast line, and which constitute not only sea ports for that country, but also for Czecho-Slovakia, Austria, Hungary, Roumania and part of Russia. The article furnishes particulars of the facilities and trade of these ports as they existed in 1939, of the devastation sustained by them during the war, and describes the engineering methods adopted for carrying out rehabilitation, together with an outline of the possibilities, and decisions already arrived at, in respect to future development.

The extent of the damage inflicted upon the ports by vanquished and victors alike surpasses anything which occurred to ports in the United Kingdom. The clearance of the debris of breakwaters, quays, sheds, warehouses, bridges, water and electric mains, cranes and wrecks of vessels, presents an heroic story of achievement accomplished with great rapidity. It appears that the first post-war ships berthed in the ports in 1945, and that as a result of the reconstruction methods adopted, Gdynia and Gdansk were capable of handling 7,700,000 tons of goods during 1946, and that the three ports, helped to some extent by the smaller ones along the coast, handled approximately 16,000,000 tons in 1948.

In pre-war days sea fishing was an important item in Polish economy, and it is interesting to see that, due to the greatly extended coast line, the opportunities now presented are to be developed. Foremost is the decision to build a new fishing harbour at Swinoujscie, which is 30 hours steaming nearer the Icelandic fishing grounds than Gdynia, and appears to be singularly well placed for development of both this industry and the intended oil and coal bunkering station. The description of the main features of this new harbour and installations indicates that all aspects of the project have been carefully considered.

Turning now to the engineering features of the rehabilitation and reconstruction work, it is to be noted that the quays and wharves and breakwaters in Gdansk and Szczecin were not damaged so extensively as those of Gdynia. The majority of them in the latter port were composed of reinforced concrete caissons, and it speaks well for the stability of this type of structure, as opposed to the platform on piles type, that the caissons appear to have so well resisted the violence of the explosion of heavy bombs and of the systematic demolitions carried out by the Germans.

Repair of the breakwaters consisted of renewing the damaged tops by mass concrete platforms and side walls placed under water by means of "tremie" pipes, it being noted that at the Port of Gdynia there is no tide, and by complete replacement of too badly damaged caissons by new ones, the method of launching of which is interesting. Caisson quays were repaired and renewed in a similar manner, and a short length of open piled wharfing by an orthodox type of R.C. platform wharf on piles, with front and back sheeting however of timber, which being wholly submerged, no doubt will last many years.

The methods which were adopted in varying circumstances for straightening the quay line, where caissons had been displaced in their foundation beds, should be examined as showing considerable ingenuity and economy. A further type of "platform" wharf worthy of note, with in this case front sheet piling of Larssen steel piles, was used at Szczecin for new quays situated in ground strata composed of mud and peat overlying sand.

As to the future development of Polish ports, there seems to be no doubt that if the industrialisation of Poland, together with an improving standard of living of its population are to be attained, then the improvement and extension of the gateways of commerce are essential preliminaries, and this appears to be thoroughly realised. Thus we see, apart from repair works, that a six-year plan has been evolved for further quays and basins at the three ports under review, and that in this respect, the site and geographical position of Szczecin offer greater possibilities than those at either Gdansk or Gdynia.

We can only hope that many years of stable relations with her immediate neighbours, and a steady improvement in economic conditions throughout the world, will enable the Polish people to press forward with their plans for port development, and that the wider national aspirations with which they are imbued will ultimately be fulfilled.

Quay Layout.

In this issue, we are publishing an article by Mr. Herman Jansson, Chief Engineer to the Stockholm Harbour Board, dealing with problems concerning the layout of modern deep-water quays for the handling of general cargo. The subject is one of great interest and importance, and Mr. Jansson has put forward a number of arguments and suggestions, in the hope that the usual practice at other ports can be compared, with a view to arriving at a form of cargo-handling procedure and quay layout which might perhaps encourage more rationalisation in dock routine and quay design.

The type of berth does not usually have a great bearing upon quay facilities, for whatever form docks may take—straight or marginal quays or, alternatively, jetties or embayments—the general layout will not be greatly affected. A consideration which has a particular influence upon quay facilities however, is the prepondering type of cargo which has to be handled, and also the proportions of cargo which will reach or leave the quay by railway and road, or which will leave the ship by lighter.

Editorial Comments—continued

As far as most Continental and United Kingdom ports are concerned, large quantities of goods and raw materials are imported, not only for the local populations, but for storage, distribution, and sale to other parts of the country. In such cases, warehousing of goods, forms an extensive part of the normal business of the docks, so that warehousing facilities, in the form of multiple storied transit sheds, are a special feature, for example, in the ports of Manchester, Liverpool and Bristol, while at the London Docks separate warehouses are more in evidence.

Of great importance is the choice of quay cranes as opposed to the use of ship's derricks for handling cargo from or to the vessel, and as Mr. Jansson suggests, this problem should have special attention. The relative merits of the two systems are mostly well understood, and the continued use of each appears to rest largely upon custom, but so far as we are aware, there have been no published results of comparative tests of the two methods where quay conditions are similar.

In the case of United States and Canadian ports, it is often stated that the unpopularity of quay cranes is partly due to their heavy first cost, and also to the objections of labour, as the use of cranes appreciably reduces the number of men employed in each hatch gang. This latter is a question which is becoming increasingly important, and the high initial and maintenance costs of quay cranes is a factor which is causing some port managements to seriously consider the elimination of the 30-cwt. quay crane for general cargo handling.

The trend of design of modern cargo vessels themselves is also a factor of great significance, and we should like to see a greater degree of consultation between shipowners and dock authorities regarding this important point. In this connection, the remarks of the President of the National Federation of American Shipping, concerning shipboard cargo gear, which will be found in a short report which also appears in this issue, are of special interest. It also should be borne in mind that many colonial and far eastern ports are not equipped with cranes, and depend entirely upon ships derricks for unloading cargo, and it is contended that it is uneconomic to provide ships with expensive cargo handling apparatus, if it is only to be used during these long-distance voyages for its use is not generally required at European ports.

It is clear that local conditions and customary methods of working vary considerably at different ports, and there probably are not two ports in which custom and practice are exactly similar, and indeed, most ports are widely divergent. Nevertheless, the comparative study of ports and of their methods of working is bound to be helpful and instructive. With regard to the ports of the United Kingdom, it may be said that, prior to nationalisation, they were in active competition with one another and spared no effort to obtain increased consignments of cargo or to win the support of additional shipping companies. Little criticism can be directed against this practice, except that in a country so small as Great Britain, uneconomic expenditure on dock facilities may sometimes have been induced, but it is certain that under these competitive conditions, the ports were keenly alive to the necessity of reducing costs by efficient dock practice and cargo-handling methods.

On the other hand, although two years have passed since nationalisation of United Kingdom ports was effected, there still appears to be no organised effort at collaboration and exchange of information, either technical or operational. We therefore suggest that the value of the publication and interchange of data and information, should be more fully emphasised as being a logical alternative to the old competitive system. In this respect, as we have already suggested in previous issues, the Dock and Harbour Authorities' Association seems now to be in a singularly favourable position to enlarge the scope of its interests and activities on behalf of the ports of the United Kingdom.

In subsequent correspondence with Mr. Jansson, he expressed the hope that his article would induce a wide discussion of the problems concerning quay layout, through the medium of this Journal, and there is no doubt that the greater the dissemination of information of this nature, the more possible will be the quicker "turn round" of the world's shipping. We are therefore especially fortunate in having received from the American Association of Port Authorities several papers, read at their recent Convention, dealing with the same topic, and if space permits we hope to refer to these in following issues.

Water Pollution Research.

The Report of the Water Pollution Research Board of the Department of Scientific and Industrial Research has been published recently.

Early in the year the programme of work of the Research Laboratory was reviewed by the Board, who considered whether the resources of the Laboratory available were being used to the best advantage of the nation. No major change in the programme of research was recommended, since almost all the work in progress was on problems of immediate importance to industry, to local authorities, or to other public bodies. Although much of the work of the Laboratory—unlike that of some of the other laboratories of the Department of Scientific and Industrial Research—is not of the kind which leads directly to greater industrial productivity, the disposal of industrial wastes and of sewage, and the preservation of the purity of water supplies, are matters of the first importance. Some of the investigations which have been undertaken on purification and disposal of waste liquors have been, moreover, of direct profit to industry in suggesting improvements in manufacturing processes or methods of reducing losses of valuable materials.

The Board's work during the year has been mainly concerned with the treatment of sewage by different biological processes and methods of filtration, together with investigations of industrial trade waste waters. Important procedures, with results and recommendations, are detailed in the Report.

Of the future investigations to be undertaken, probably the one most interesting to Dock and Harbour Authorities is an exhaustive examination of the causes of silting in the Thames Estuary. As was pointed out in these columns in our issue of August last, this is to be carried out in conjunction with the Department's Hydraulic Research Organisation, on behalf of the Port of London Authority. A feature of this survey is, that it is being made concurrently with experiments with a large model of the tidal portion of the Thames.

The causes of siltation in estuaries are but little understood, and it seems that these combined investigations for the P.L.A. may be the first really serious attempt, on so large a scale, to elucidate them.

Prior to the recent war, however, a somewhat similar research was made by the Water Pollution Research Laboratory, for the Mersey Docks and Harbour Board, and this established the interesting fact that, in the River Mersey, most of the material taken from the upper estuary by dredging, is brought in from the sea, rather than from fresh water streams; also, that crude sewage discharged into the estuary has no significant effect upon the rate of sedimentation of the flocculated mud carried to and fro by the tide, nor on its resistance to erosion after it has been deposited.

In the case of the River Thames, however, whatever may be the result of the investigations, no doubt we shall see, in the future, an extension of the principle involved in the construction of the West Middlesex Main Drainage Scheme, which has proved so successful, i.e., the concentration of sewage treatment in one large works and the elimination of a number of small and often inefficient Borough and Urban District disposal works, whose effluents reach the Thames. The West Middlesex sewage works, incidentally, employs as the main purification processes "activated sludge" and sludge disposal by "digestion," and deals predominantly with domestic sewage, although there is a considerable and growing proportion of organic trade wastes.

In these days of advanced scientific knowledge, the purification of sewage and trade effluents has resolved itself into the simple question of what standard of purity it is desirable or necessary to adopt for any particular stream—that is to say, it is subject to limitation only, it seems, by considerations of cost and the necessary legal powers to impose the standard decided upon.

The work of the Water Pollution Research Board is of considerable value, and the Report for the year 1948, which is published by H.M. Stationery Office, price 1s. 3d., by post 1s. 5d., will be of interest to many industrial undertakings and those Authorities charged with the duties of River Conservators.

Polish Ports

A Review of their Post-War Reconstruction

By STANISLAW HUCKEL, Dipl.Eng.
(Lecturer at the Technical University at Gdansk).

I.—The description of Polish Ports, as they were in 1939, and their functions

When comparing the three principal Polish ports, Szczecin (Stettin), Gdansk and Gdynia, we can easily discern the following main differences:—

(a) The ports of Gdansk and Szczecin were built at the mouth of rivers which were once the main routes of communication with the hinterland, whereas Gdynia is a port built artificially on a stretch of open coast.

(b) Gdansk and Szczecin are ancient ports which grew through the centuries and were extended, when the necessity arose, in a more or less chaotic way. The construction of the port of Gdynia was commenced about 25 years ago according to a plan meticulously elaborated, which foresaw the possibility of further enlargement of port basins and other installations.

From those two main differences originate all others, which are of a rather secondary character:—

(c) Breakwaters very difficult to build, and a costly investment, have played an unimportant part in the construction of the ports of Gdansk and Szczecin, but are of the utmost importance in Gdynia, where they have a total length of over 2¼ miles.

Key map showing the situation of the main Polish Ports.

(d) Nearly 70 per cent. of the quays in Szczecin and Gdansk are of light and primitive construction, securing only the natural banks of the river; in Gdynia 85 per cent. of the quays are of modern construction, permitting the mooring of ocean-going vessels drawing 26—36-ft. Most of the basins were dredged in the mainland.

(e) In Gdansk and Szczecin the approach to the loading and discharging berths is, on the average, long and difficult to navigate; the location of different basins and the intercommunication between them are very often inconvenient. On the contrary, the approach to all berths in Gdynia is safe, the position of all basins centralised, the internal communication simple and perfect.

(f) Most of the sheds, warehouses and stores in Gdansk and Szczecin were out-of-date—did not comply with modern requirements—and had been chaotically built over centuries without any particular planning. In Gdynia all warehouses, silos, cold stores, etc., were built during the last two decades; they are, therefore, modern and serve their purpose well. The whole port area being divided into several commodity zones, all similar goods are stored in the different parts of the port especially assigned to them.

(g) Loading and discharging facilities in Gdynia, though on a smaller scale in pre-war days than in Szczecin or Gdansk, were more modern and efficient.

The following table gives comparative figures pertaining to the facilities and equipment of the three ports mentioned as they were in 1939:—

	GDYNIA	GDANSK	SZCZECIN
Total length of breakwaters	2¼ miles	700 yards	—
Water area of the inner harbour	550 acres	525 acres	970 acres
Water area of the inner and outer harbour	2,200 acres	—	2350 acres
Total length of quays	7 miles	19¼ miles	19¼ miles
Total length of quays for the use of ocean going vessels	6¾ miles	6¾ miles	4¾ miles
Covered storage space	3 mil. sq. ft.	3,1 mil. sq. ft.	1.3 mil. sq. ft.
Cold storage area	250,000 sq. ft.	—	157,000 sq. ft.
Storage capacity of silos	10,000 tons	116,000 tons	67,000 tons
Number of loading appliances /mech./	87	101	124

It is necessary to outline briefly the historical background of the development of these ports to enable the reader to understand fully their mutual position and their respective functions in 1939.

As the outcome of the partition of Poland at the end of the 18th century, the port of Gdansk was cut off from its natural hinterland. Germany regarded it as a second-grade port and directed the bulk of her Baltic trade through Szczecin. Owing to this fact Szczecin became, by 1913, the biggest port on the Baltic at the expense of Gdansk, which lost to Szczecin most of its foreign trade and kept only some coastwise traffic.

As the result of the first World War and the Versailles Treaty, the Free City of Gdansk was incorporated with Poland and formed with her a customs union. The port of Gdansk became in the early twenties the only deep sea port of the Republic of Poland. Gdansk regained from Szczecin the major part of cargoes destined for Poland, and in 1929-1932 topped the list of Baltic ports having the biggest traffic on the Baltic. It was only the hostile politics of the Senate of the Free City of Gdansk which compelled the Polish people to seek complete independence by building the port of Gdynia, situated about 20 miles north-west of Gdansk. Commenced in 1926, the port of Gdynia, shortly before the second World War, surpassed both its rivals: Gdansk and Szczecin.

The coming to power of Hitler brought with it a change of attitude towards the port of Szczecin. Subsequently more German ships were directed to Szczecin, so that it regained its position as the biggest port on the Baltic, and held it from 1933 up to 1936.

As from 1937 Gdynia, with its traffic of over 9 million tons of goods handled, as compared with Gdansk's 7.2 mill. tons and 8.3 mill. tons of Szczecin, has taken the lead on the Baltic.

If we now take the present position of these three ports, we will see that very little can be learnt from the analysis of the pre-war structure of their trade. Two of them were cut off from their natural hinterland, and moreover, the traffic in Gdansk, due to political reasons was limited, while that of Szczecin was artificially boosted, though it was not an economical proposition.

Enormous political and economic changes, the result of the last world war, altered the picture completely, which made the task of the planners even more difficult.

Polish Ports—continued

Up to 1939 the ports of Szczecin, Gdynia and Gdansk dealt mainly with bulk cargoes, the chief commodities being coal and iron ore. The only difference between them was that in Szczecin the volume of imports was twice as large as that of exports, while in Gdynia and Gdansk exports were four times larger than imports. The explanation of this fact may be easily found in the economic structure of their hinterland.

The rest of the Polish ports (Swinoujscie, Kolobrzeg, Darlowo, Ustka, Leba, Wladyslawowo, Hel, Jastarnia, Puck, Elblag, etc.) were mainly visited by cargo and passenger ships trading coastwise and/or by fishing craft. A few of them were centres of the shipbuilding industry and marine engineering. They could be classified on principles similar to those applied to Gdynia, Gdansk and Szczecin, but as they are small and of local importance only, this seems to be unnecessary.

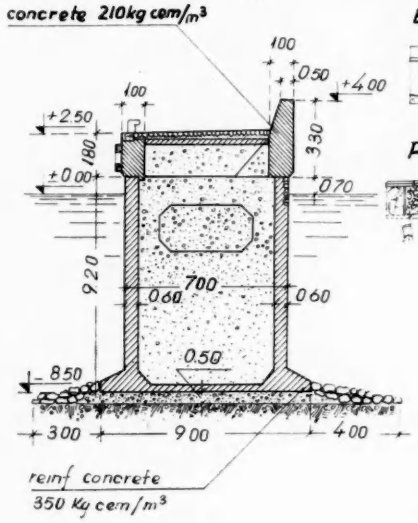


Fig. 1

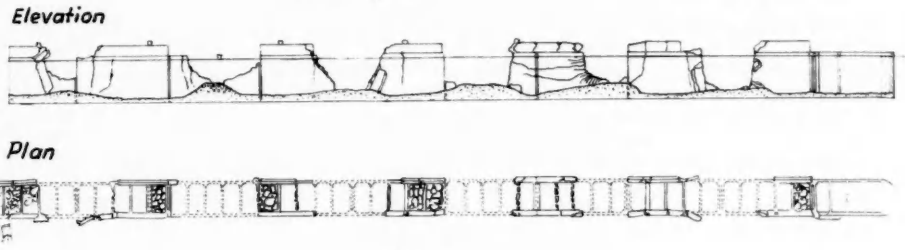


Fig. 2

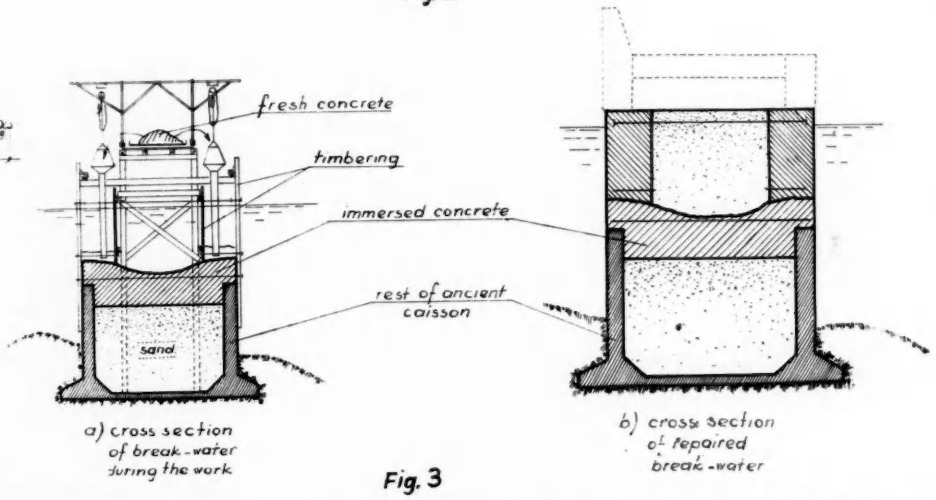


Fig. 3

II.—Changes in the character of the Polish Ports which occurred during the war. War damage

As the result of war and the devastations connected with it, big changes occurred in all three Polish ports during the period 1939-1945. It is possible to classify the causes of these changes as follows:—

(a) Modifications done by the Germans to adapt the ports to their military functions.
(b) War damage:
  1. Owing to air-raids.
  2. Owing to artillery shelling and street fighting during the action in September 1939 and in 1945.
  3. Blasting of installations and buildings and other deliberate damage done by the retreating German troops.
(c) Mining of roads, warehouses, railways, bridges, waterways and basins by defending troops.
(d) Blockade of the entrances to the ports, their basins and canals by scuttled ships, floating docks and cranes, and other wrecks.

Considering each one of the Polish ports separately, we notice that the port of Gdansk retained its commercial character during the war and was never used as a naval base by the Germans. It escaped both allied air-raids and premeditated damage by the German troops. But as a result of the siege by the Russians in 1945, over 90 per cent. of all sheds and magazines were completely destroyed, all grain silos seriously damaged, and nearly all buildings housing port administration levelled with the ground. Loading and discharging appliances in the port were either blasted or damaged by artillery fire and aeroplanes. Water and electric networks were put out of order.

The entrance to the harbour and basins were blocked by wrecked ships and craft, the waters of Bay of Gdansk infested with mines, the whole port estate and the city itself guarded by extensive land-mine fields.

On the other hand, practically no damage was done to the breakwaters and quays, the only exception being the south part of Westerplatte.

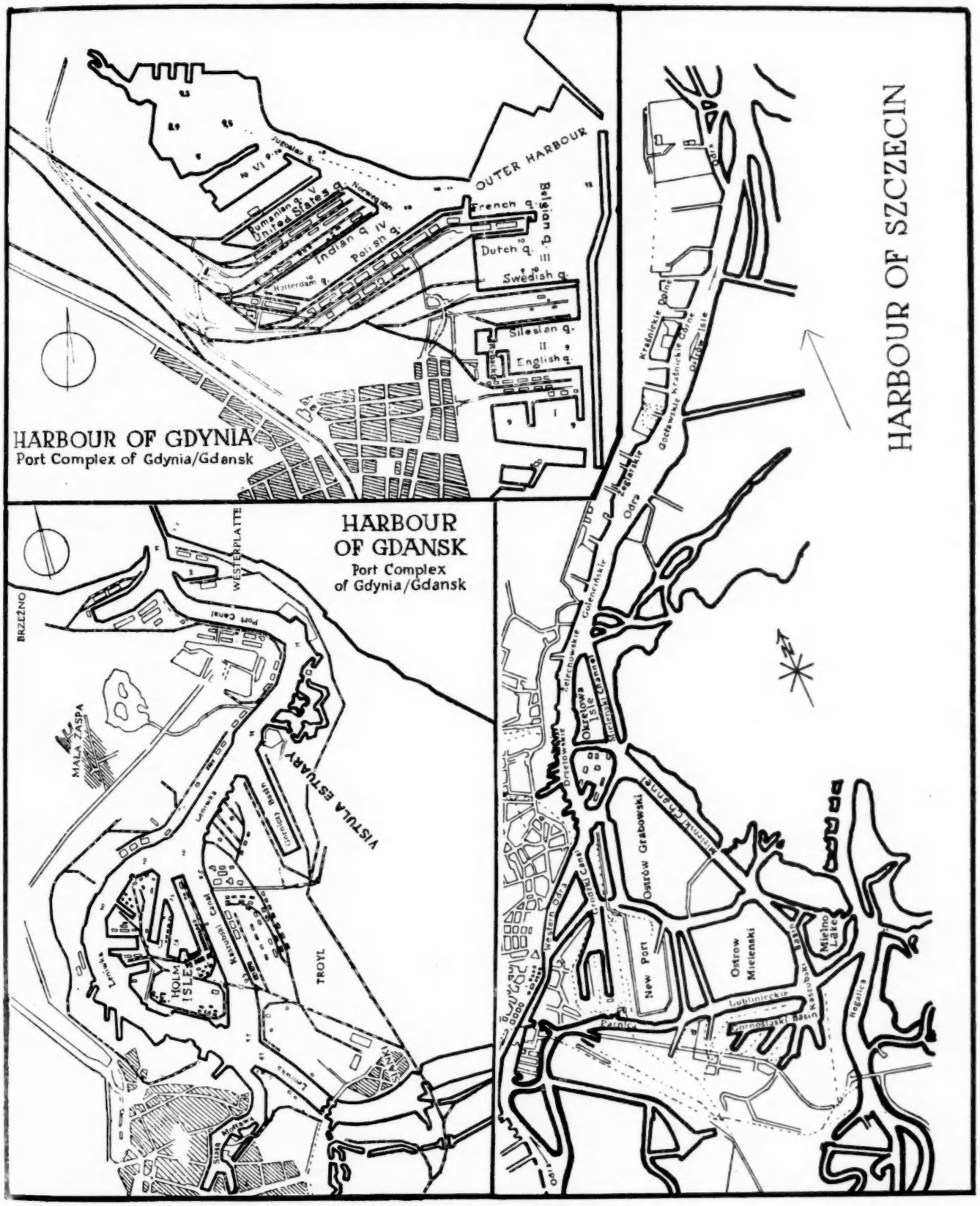
A serious blow and the most important obstacle to quick recovery was the complete destruction of the city of Gdansk, which can be estimated at 90 per cent., and of Gdansk's suburbs at about 50 per cent.

After the liberation, a fresh start had to be made with the reconstruction of the city—apart from that of the harbour and its installations—as in its devastated condition it would have had crippling effect on the further development of the port and the well-being of its personnel.

The fate of the port of Gdynia was quite different. After the capture of Gdynia in 1939, the Germans decided to change the town and the port into a naval base. Munition plants, gun and ordnance factories were accommodated in modern warehouses and sheds, and buildings of the port administration were converted into hospitals and barracks. New factories were built within the harbour estate with adjoining boiler installations for hot-water supplies and central heating. Concrete air-raid shelters, pill-boxes and anti-aircraft gun sites could be found everywhere.

When, after liberation, the Polish authorities took over the port of Gdynia and tried to use it in its pre-war capacity, they found dozens of useless structures, power and pipe lines, etc., which had to be cleared. This hampered the construction considerably and meant, of course, a serious delay. Damage done to port installations by air-raids and artillery shelling was very heavy, too, as

Polish Ports—continued


HARBOUR OF GDYNIA
Port Complex of Gdynia/Gdansk
OUTER HARBOUR
Jugoslav q.
Rumanian q. V
United States q.
Norwegian
French q.
Belgian q.
Indian q. IV
Polish q.
Dutch q.
III
Swedish q.
Rotterdam q.
Silesian q.
II
English q.
HARBOUR OF GDANSK
Port Complex of Gdynia/Gdansk
WESTERPLATTE
Port Canal
BRZEŹNO
MALA ZASPA
VISTULA ESTUARY
Lemwerder
Liebenau Basin
HOLM ISLE
TROYL
Siding Montwerk
HARBOUR OF SZCZECIN
Kraśnickie port
Kraśnickie Cornie
Odra Zachodnia
Odra
Zdrojowe
Zdrojowe
Kanał Kolejowy
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Wschodni Kanał
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Polish Ports—continued

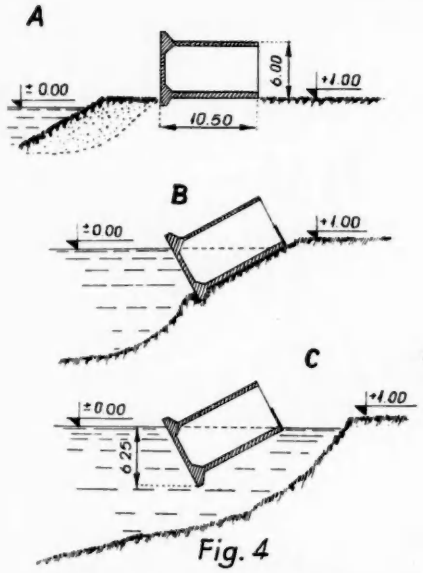

Fig. 4

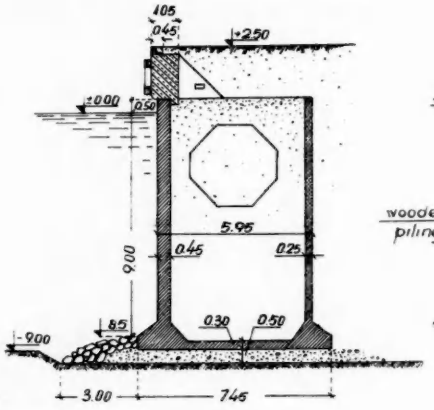

Fig. 5

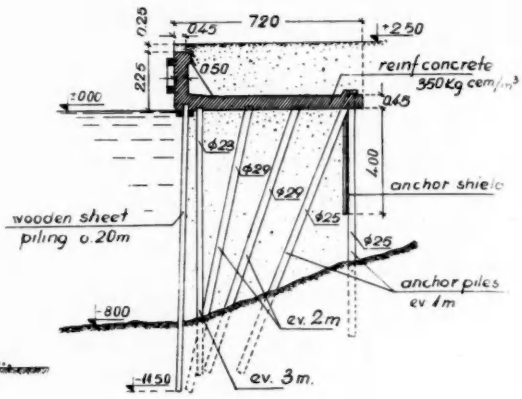

Fig. 6

nearly 50 per cent. of all buildings—mostly sheds with wooden roofs—were burnt down and it was impossible to find even one which did not need some repair.

However, the worst damage was done by the systematic demolition of breakwaters, piers, embankments and cranes by the retreating German troops. Due to the rapid advance of the Russian troops, one part of the installations escaped destruction, but the Germans had still enough time to damage beyond repair all breakwaters and about half of the total length of the quays. At the same time they had destroyed a great number of cranes, coal-tippers, pneumatic grain loading plants, 50 per cent. of which had to be scrapped. The rest were repaired or rebuilt by the Polish authorities with a big outlay of capital and labour.

Among other installations a big, modern coal-tipper, 32 tons capacity, and a transporter crane, one of the biggest in Europe, had been blown to pieces. As the Germans used large quantities of explosives to blow up the wharfs, the foundations of numerous buildings constructed on those wharfs were badly shaken and some of them collapsed, among others, the fish stores and fish sheds on the "British Quay".

Apart from breakwaters and quays, the Germans blew up all bridges in the harbour (with the exception of the smallest one), all water storage tanks, water-pump station and tower, paralyzing the whole life in the harbour and adjacent city.

To complete the picture of chaos and destruction in which the Polish authorities found the port of Gdynia, it is only necessary to say that the waters in and outside the port were mined, dozens of wrecks lay in the basins, canals and approaches, the biggest of which—the German battleship, "Gneisenau," sunk in the main entrance to the port—has not yet been removed completely even to-day.

The town of Gdynia itself was not seriously damaged and has completely recovered by now.

If we now take into consideration the third main port on the Polish coast, we shall see that the damage done to the port and city of Szczecin was not so extensive as in Gdynia or Gdansk. Szczecin suffered most from allied air-raids and shelling by Russian artillery during the siege and street fighting in 1945. About 50 per cent. of warehouses and transit sheds, 60 per cent. of cranes, and 10 per cent. of the total length of quays and piers were destroyed. There was practically no road or rail communication, because nearly all bridges were blown up by German demolition squads. The city of Szczecin was in a comparatively good condition.

No serious damage was done to harbour installations in the smaller ports like Kolobrzeg, Ustka, Darlowo and Wladyslawowo, though the inhabitable areas, adjacent to these ports, sustained some damage. Only in Wladyslawowo the Germans sprang a breakwater about 100 yards long.

Table of war-damage in the three main Polish Ports.

	Gdynia	Gdansk	Szczecin
Destroyed breakwaters	90%	18%	—
Destroyed quays and wharfs	45%	15%	10%
Sheds and warehouses :			
(a) requiring minor repairs	50%	5%	50%
(b) requiring capital repairs	25%	7%	20%
(c) to be completely rebuilt ...	25%	88%	30%
Loading appliances :			
(a) requiring minor repair only ...	40%	35%	40%
(b) requiring capital repair ...	10%	25%	20%
(c) damaged beyond repair ...	50%	40%	40%

III.—Principles of rehabilitation and further development of Polish Ports

When the ports were taken over in 1945 by the Polish authorities, the task of reconstruction was boldly tackled by them.

The work done during the period of the last four years can be divided into two stages:—

(1) During the first two years the efforts were chiefly concentrated on the clearance of rubble and wrecks from at least a certain area in each of the main ports to enable the ships with supplies, so badly needed by our country, to enter the ports. Use was made of the least damaged quays and of the installations which could be most easily repaired.

(2) The next two years, as well as the present year, have been mainly devoted to the reconstruction and extension of the existing facilities in the Polish ports, which have an important role to play in the ever expanding trade of Poland. Extensive works are going on everywhere, according to the plan drawn up by our economists and engineers, which takes into account not only the present needs but also the more distant requirements of the Polish foreign trade.

The first ships berthed in our ports as early as July, 1945. The task which lay before Polish engineers and workers was to clear the waters and harbour estate from both sea and land mines, to lift or disperse wrecked ships and installations in waterways and basins.

They had also to mark the fairways with buoys, lights and beacons; to clear the rubble lying on the quays; to erect temporary sheds and warehouses; and to restore disrupted communications, mains, water and gas supplies.

It was a race against time. The least damaged quays were chosen and the teams of road-workers, bricklayers, carpenters, electricians, mechanical and hydro-engineers were working day and night to repair the damage and erect new buildings and installations.

How difficult a task it was can be appreciated when one takes into account that, owing to the lack of mechanical equipment,

Polish Ports—continued

the major part of the work had to be done by hand, with the help of such primitive tools as picks or spades.

Places chosen in Gdynia as most suitable for such speedy repairs were:—

The west part of the Polish Quay—for the handling of general cargo.

"The Eng. Wenda" Pier—for the handling of bulk cargoes.

"The Pomeranian" and "The English" Quays—for the use of fishing vessels.

"The Indian Quay"—for a site for the local industry.

The respective areas in Gdansk were:—

Free Zone and the Entrance Canal—for the handling of general cargo.

"Vistula Quay"—for bulk cargoes.

In Szczecin the first quays to be reconstructed were the river quays on the west banks of the Oder.

As a result of the adoption of this system, the ports of Gdynia and Gdansk were capable of handling approx. 7,700,000 tons of goods in 1946.

At the end of the first stage of the reconstruction programme, i.e., on January 1st, 1947, there were 30 working cranes and approximately 1,000,000 sq. ft. of covered storage space in Gdynia; 26 cranes and 400,000 sq. ft. in Gdansk; and 7 cranes and 650,000 sq. ft. of warehouse space in Szczecin.

Further work is in full swing according to the plan drawn up for three years ending in December, 1949. This is mostly major structural work pertaining to the reconstruction of badly damaged breakwaters, quays, piers and warehouses, and also the erection of new ones.

As concerns new investment, there are two projects which will be of some interest to the reader: the construction of a new coal and iron ore harbour in Szczecin and the building of a large fishing harbour in the neighbourhood of Swinoujscie.

The description of all these projects will be found elsewhere in this article. At present we will only mention that the work done has enabled Polish ports to deal with 12,200,000 tons of goods during the first three quarters of 1948, which was equal to 65 per cent. of their pre-war capacity. The Gdynia-Gdansk share was 9.5 million tons; that of Szczecin 2.1 million tons; the rest being handled by other smaller Polish ports.

As concerns the structure of our sea-borne trade, there was a large gap between the volume of exports and imports, the former being four times larger than the latter (9.9 million tons against 2.3 million tons). The main commodity in import was iron ore (1.2 million ton); in export, coal and coke (9.1 million tons), which also accounts for the lack of balance between the volume of goods exported and imported. The tonnage of general cargo leaving and entering the country by sea was approximately the same.

IV.—Reconstruction of breakwaters and quays at Gdynia

From the point of view of an engineer, the task of the reconstruction of breakwaters and quays at Gdynia was one of the most interesting.

1.—BREAKWATERS.

The construction details of Gdynia's breakwaters, well known from different articles in the press, are shown in Fig. 1. Their main structure consists of a great number of caissons made of reinforced concrete, which form the foundation of the breakwaters. The caissons are set on a base of loose stone and filled with sand; their walls are partially covered with a protective layer of stone, gravel and sand. On the top of these caissons are placed two concrete walls, one facing the sea, heavily built and rising to a height of 13-ft. 6-in. above the sea level, and another lower and of lighter construction, facing the inner harbour. The space between these walls is filled with sand and covered with concrete flags or paving, thus protecting the roadway from the destructive action of the waves.

When the German troops withdrew from Gdynia in 1945, the breakwaters practically did not exist. German demolition squads sprang the breakwaters every few yards, so that the breaches in them accounted for more than half of their total length. The walls above the sea level were completely destroyed, the caissons cracked, broken or destroyed beyond repair. Fig. 2, showing the result of an inspection by a diver of one part of the breakwater, illustrates best how extensive was this mischievous damage.

Great difficulties were encountered during the reconstruction of breakwaters in Gdynia. There were several projects as to how to tackle this job, and finally the Polish authorities chose the method explained by Fig. 3. The caissons and the sand in them were levelled by divers and a concrete platform laid, using the

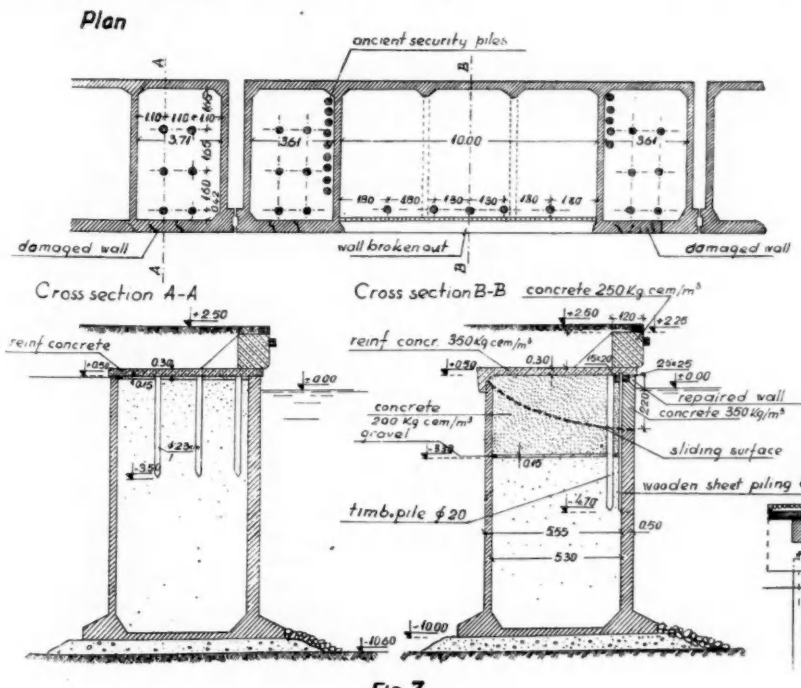

Fig. 7

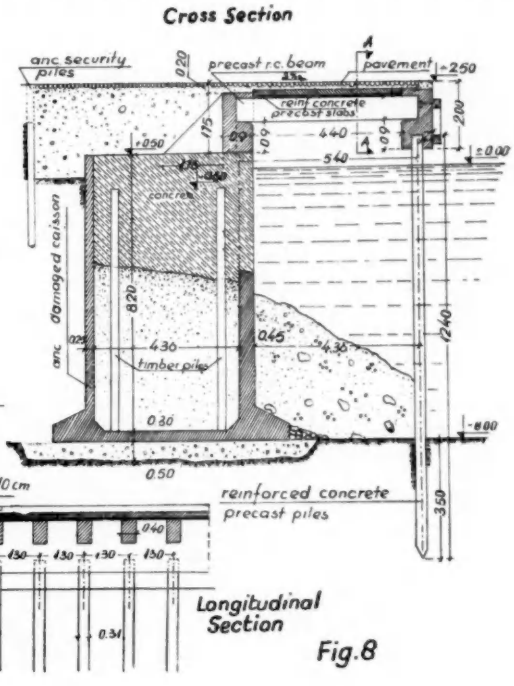

Fig. 8

Polish Ports—continued

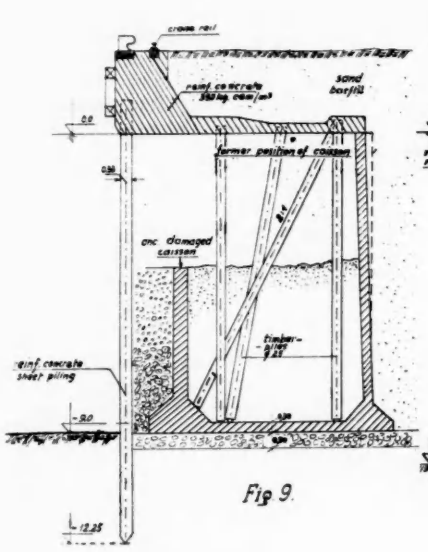

Fig. 9.

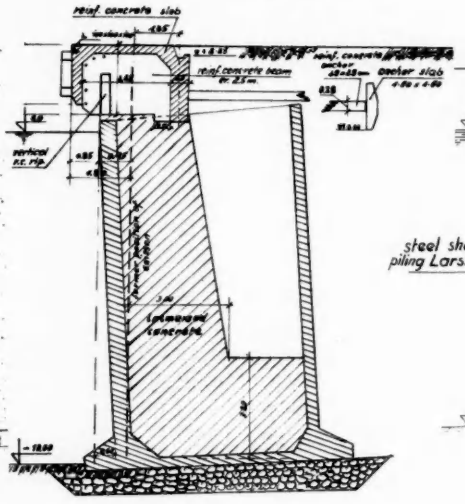

Fig. 10.

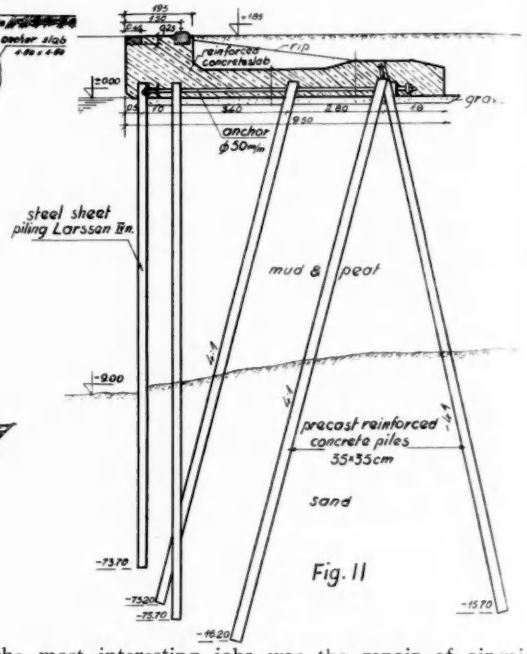

Fig. 11

"Contractor" method. On this platform, concrete walls were erected and the space between them filled with sand. The construction of the remaining structure was the same as previously described.

Apart from the reconstruction of the damaged breakwaters, it was necessary to lengthen the eastern breakwater by another 575 yards to form a canal between the basins No. 2 and 3. This new breakwater is of the same construction as used in pre-war years. Caissons are prefabricated high and dry on a stretch of open coast near the water line, where they remain till the concrete hardens (Fig. 4). Then the sand beneath them is removed by a suction dredger, the caissons are launched and towed to a place where they are sunk into position. Prior to this, the divers have prepared and levelled the stone bed on which the caissons rest. The caissons are left sunk for about a year, so as to enable them to settle. Only when they have done so, can the construction of the walls and roadway be commenced.

Three breakwaters in the inner harbour—"Silesian," "English" and "Wilson's"—sprung by the Germans, cannot be repaired and will have to be completely demolished and new ones built in their place. The removal of the remnants of these breakwaters presents, however, a big problem, as the weight of several pieces is in the region of hundreds of tons. Such heavy pieces cannot be lifted by the existing floating cranes, therefore it is planned to raise them by the help of specially built salvage pontoons.

2.—QUAYS.

A great majority of quays in Gdynia (about 80 per cent.) are built on caissons and their method of construction is similar to that of breakwaters. They are shown in Fig. 5.

Only a short length of the embankments is of light construction, consisting of concrete slabs resting upon piles. Below the water level there is a row of 8-in. wooden sheet piling supported partly by the pier structure and partly by trestles spaced evenly at every metre of the quay. Above the water level there is a concrete facing with fenders and stone coping on top. The sheet piling and trestles are covered by pre-cast reinforced concrete slabs supported by several rows of vertical and diagonal piles (see Fig. 6).

Fortunately enough the most important quays—those dealing with general cargo and coal exports—had sustained only minor damage and could be comparatively easily repaired. In this way the most urgent needs of the Polish trade could be satisfied, using only the repaired quays, and, in the meantime, unceasing work was going on in other zones of the port. Quays in the fishing harbour were repaired next, followed by those of the previous yacht basin.

One of the most interesting jobs was the repair of air-raid damage done to the "Dutch Quay," which was built on caissons by the method previously described. Owing to the blast, whole parts of the side walls were missing and the remaining walls were cracked.

A special method of repair (illustrated by Fig. 7) was worked out. Sheet piling was driven into the caisson along the damaged wall, the sand inside was levelled and the caisson filled with concrete. The breach in the wall was filled with concrete and also all cracks in the walls. The neighbouring caissons were covered with concrete slabs resting upon wooden piles, and the whole structure was finished by building an embankment along the quay. This system of repair was also adopted for the recontsruction of longer stretches of the embankment.

Another difficulty encountered during the repair of damaged quays was that the caissons had not only been damaged, but also shifted from their original position. In this case simple repair of the caissons would not have been very effective, as the front line of the quay would have remained uneven. To overcome this difficulty, it was necessary in many instances to set further forward the new front line of the quay.

Figures 8, 9 and 10 show the most characteristic solutions of this problem.

The construction of the new frontage on the "English Quay," used by fishing vessels (see Fig. 8), was done in the following way: damaged caissons were repaired, using the method previously described; all along the quay, concrete pillars were driven into the foundation layer and a longitudinal concrete beam set on them parallel to the old frontage of the quay. Prefab concrete beams were laid on the caissons and the longitudinal beam and mixture of concrete cast on them. The whole structure was covered with earth up to a height of 2.5 metres above the water level.

On the Silesian Quay (Fig. 9), the damaged pier structure was strengthened by a row of concrete pillars driven on the waterside of the quay and a new quay frontage constructed from sheet piling. A few rows of piles were also driven into the caissons. The whole structure was covered with concrete and a facing was erected on the waterside of the quay.

A different method was applied to the damaged caissons and to the uneven pier line of the "Roumanian Quay". The leaning caissons were fixed into position by special reinforced concrete beams and anchors; the uneven line of the quay frontage was straightened by the complete reconstruction of the pier face above

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the water level. Fig. 10 shows the cross-section of the repaired quay.

The repair of those parts of the quay which had been built on piles was impossible, because the damage done to the piles and sheet piling was too extensive. In this particular case it was necessary to build a completely new wharf, parallel to the old one.

It is worth mentioning that the reconstruction of the quays was totally in the hands of Polish civil engineering firms, and they were also entrusted with the working out of the plans. Only the reconstruction of breakwaters was done by Danish firms.

V.—Extension of bulk cargoes zone in Szczecin

In 1947, Szczecin was chosen as the main Polish port for the export of coal and coke. Out of all the Polish ports, Szczecin enjoys the exceptional position of being located nearest to the Silesian coal mines and, on the other hand, is most conveniently placed in respect of the main consumer markets of Polish coal.

It was decided that by 1950 Szczecin should be able to handle 5.5 million tons of coal and coke, as well as 1 million tons of iron ore. To achieve this aim, both the cargo handling equipment left by the Germans, and the new quays adapted for this purpose by the Polish authorities, would be insufficient. It was found necessary to work out a quite new project.

A new site has been chosen, situated in the south-east part of the harbour, next to the existing quays on which coal and iron ore are handled.

In this way all bulk commodities will be handled in the same zone of the port, which has certain economic and administrative advantages. There is an easy access to this part of the harbour through the Melenski Canal, dug just before the outbreak of the last war. On the other hand, there is plenty of room on the site for the construction of vast railway sidings, and laying of railway tracks along the quays will present no difficulty.

The project provides for the equipment with modern cranes of three existing quays; the construction of two further quays, 600 metres long; and building of one pier, 150 m. long, on which a belt conveyor for loading coal will be erected. All grab-cranes will be delivered by Polish and Czech firms, and belt conveyor equipment by U.S. firms. Coal-tippers installed on the "Western Quay" originate from ex-German chemical works in the neighbourhood of Szczecin. They have been specially redesigned for this purpose and are coupled with belt-conveyors and special discharging chutes, which prevent breakage of coal. Extensive construction is in progress on the site of new coal-port and in the neighbouring waters, as it is necessary to dredge the basins to the depth of approximately 30-ft. The canal between Swinoujscie and Szczecin is also being dredged to a depth of 32-ft., which will permit the safe navigation of vessels drawing up to 28-ft.

The new quays are of platform type (Fig. 11) with steel sheet piling and trestles; concrete slabs are supported by pre-cast reinforced concrete piles. To speed up construction, some of them are "Franki"-piles. Due to the loose character of the ground on the site (a layer of peat and slime up to a depth of 8-10 metres) the whole length of the piles had to be reinforced.

The pier consists of a concrete platform which rests on cylindrical piles spaced every 10 metres and on caissons driven down with the help of compressed air.

The bulk cargo basins were finished by the end of 1949 and are capable of handling 5.5 million tons of coal and coke yearly. The belt conveyor will be ready by June, 1950, and then the capacity of this region will be raised to 8 million tons yearly.

VI.—Construction of new fishing harbour in Swinoujscie.

Even in pre-war days, sea fisheries played quite an important role in Polish economy, though they were restricted to a coast of some 80 miles. To-day, when Poland possesses over 300 miles of open coast, much wider opportunities exist for further development.

If we assume that, given adequate supply, the consumption of fish should be about 21 lbs. per head, the total demand would be in the region of some 250,000 tons of fish yearly. Of this quantity, inshore and short-distance fisheries could supply a maximum of 100,000 tons. The remaining 150,000 tons would have to be imported or provided by our own deep sea trawlers fishing in distant waters. If this last possibility were chosen, it would be necessary to develop our present fishing fleet and, at the same time, build new bases. The existing facilities at Gdynia are hardly sufficient at present, so it was necessary to look for some other place, located if possible nearer the new fishing grounds. The Polish West Pomeranian coast has been chosen for this purpose, and finally it has been decided to build a new fishing harbour near Swinoujscie. This place has several advantages. It is located 30 steaming hours nearer the Icelandic fishing grounds than Gdynia, which means a considerable saving of time and fuel and the delivery of better fish. Moreover, Swinoujscie possesses excellent sites for the construction of a large fishing harbour, and there is a shipyard in place built by the Germans.

The new harbour will be dredged in vast, low meadows lying along the river Stara Swina, which will permit its further development. This place is, on the one hand, far enough from the main fairway to Szczecin so as not to cause unnecessary obstruction to its traffic, and, on the other, near enough to the sea (approx. 1½ miles) to secure an easy access for fishing vessels.

It is expected that the short approach canal to the harbour will be kept open to navigation with ease even during the winter. The location of the harbour in a sheltered position on a river will obviate construction of such expensive structures as breakwaters, which would be indispensable in a sea harbour.

In its first stage the harbour will consist of one basin only, about 800 yards long and 165 yards wide, which will be equipped with all facilities required for the landing of 60,000 tons of fish in a year. In future it will be possible to dredge another two basins and thus greatly increase the existing capacity.

According to the plan, fish sheds and a fish landing quay will be completely separated from coaling and rigging quays, stores and other buildings owned by trawler companies. The former will be located on the eastern side of the basin; the latter at the entrance to the basin and on its western side. Two shorter quays will be used by fishing smacks, cutters and other smaller boats. On the landing quay, large fish sheds will be erected, having a total width of some 165-ft. They will be divided by a wall into two zones:—

(1) The water-side zone, where the fish is landed, sorted according to species and quality and inspected.

(2) The inland-zone, where the fish is cleaned, processed and prepared for further storage in the neighbouring cold stores, or for dispatch to consumer centres inside the country.

At the back of the fish-sheds there are railway sidings and behind them cold stores, ice-factories and warehouses for storing herring. Ice is delivered to the landing quay by overhead belt conveyors running over the railway sidings. Bridges are also provided over the railway tracks for communication between the quay and the warehouses and factories, and they are equipped with cargo elevators which lift trailers with fish to the level of the bridge.

The bunkering station is situated outside the fishing basin near the entrance. It is provided with oil fuel tanks and coal hoists for supplying with fuel not only fishing vessels, but also other vessels which may call for bunkers. That possibility was taken into account when this project was drawn up.

Space is provided also within the harbour estate for the buildings of port administration, for the local industry, goods railway station, parking place for motor lorries and cars. Only a fish-meal factory will be built on the outskirts of the estate, to avoid complaints about the offensive odours and fumes which it may exhale.

As the existing ship-building and repairing yards are very conveniently placed, not only will full use be made of them, but they will be modernised and adapted to the present requirements.

It has also been decided to build in the neighbourhood dwellings for dock workers and fishermen. The fishing harbour will be easily accessible by road and rail. Adjacent to it is the new railway station, Odra, built in 1947, and the pier and railway ferry plying between Szczecin and the Swedish port of Trölleborg.

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At the moment, the work is in full swing and the construction of the harbour is well advanced, and that of the cold-stores nearing completion.

VII.—Prospects of further development of Polish Ports.

It is not an easy task to foresee what will be the future trends of Polish foreign trade and, in connection with this, the volume of goods which will have to be handled by our ports. All this will depend upon the development of the industry and agriculture, future trade agreements, the economic situation of other nations and the standard of living reached by our population. Everything seems to indicate that the trade of Polish ports will show an upward tendency, due to the industralisation of our country and the improving standard of living of its population. This natural tendency will certainly be backed by the conscious action of its leaders.

It can be best expressed by the words of Mr. Rapacki, the Minister of Shipping, who, during his speech in June, 1949, said: "It is not possible to achieve the degree of industrialisation required without adequately equipped and efficiently working ports, or without an independent and strong merchant marine. Our first task is to build ports which will be technically capable of handling the goods sent to them by national industry and agriculture. Our second task is to build efficient and cheap ports which must be first-class in every way: modern, specialised, well-equipped, organised and served by numerous regular lines, connecting them with all ports of the world. Our third task is to build competitive ports staffed with well-trained men, ports which would be able to give full satisfaction to all countries forming their natural hinterland, to attract new customers."

Although in this short excerpt from Mr. Rapacki's speech an emphasis is laid more on the necessity of good organisation of the ports and their commercial efficiency than on their technical perfection, it is obvious that such efficiency can be attained only if their technical equipment is without reproach. The speech implies that the ports will be developed when the necessity arises and well in advance of it.

To-day, at the beginning of the new six-year plan, the port authorities understand that in the immediate future they will face the problem of building new quays and basins. In connection with this, it will be interesting to examine briefly the possibility of the further extension of the Polish ports.

In Szczecin, the new bulk cargo harbour is under construction and it is expected to satisfy the requirements of Polish trade for years to come. At present the reconstruction and extension of general cargo quays is under discussion. As we may see on the map provided, there is plenty of room for such extension. In the central area only, enclosed between the rivers Oder and Regalica and the canal Melenski, there is enough space for the dredging of several new basins and piers, and in this way it is possible to double the present capacity of the port. Even more space for new building can be provided by the lake Dabie, lying to the east of the Melenski Canal, though, as it is to-day, the lake is not navigable.

In any case, it is now too early to foresee future requirements and the direction in which further development will go.

The plan of development of the port of Gdansk is much more precise. The main port canal, extending from north to south, will form the backbone of the new port. On the terrains extending to the west, at least four basins will be dredged, but their exact shape is not yet known. Further to the south the canal will widen, thus forming a basin provided with dolphins, at which cargo will be transloaded from sea-going ships to barges and vice-versa. This dolphin-basin will meet the river Leniwka, which is the main waterway in Gdansk. All harbour terrains are flat and are admirably suited to this purpose.

Perhaps the least fortunate is the port of Gdynia, which has space for two further basins only. A shipyard built during the war by the Germans in the western part of the harbour hinders considerably further development, as it occupies the terrains chosen in pre-war days for this purpose.

As concerns the smaller ports, they were rather under-developed and neglected by the Germans. The handling capacity of these ports can be considerably increased if they are adequately equipped and dredged. No immediate necessity arises at present for their further extension.

Each of the smaller ports has its particular duties to accomplish. Most of them will be used as bases by vessels fishing in the Baltic and will be provided with cold-stores, ice-factories and other equipment. Some of them—Ustka, Darlowo, Kolobrzeg—play an important role in our coal export trade. In Swinoujscie a big fishing harbour is being built, and it is expected that this port will also serve as a bunkering station for the ships navigating the southern Baltic.

This closes the brief outline of the work which has been done since the war in the Polish ports and which will be done in the nearest future.

It will be gratifying if this article arouses some interest among British and Overseas readers and acquaints them with the efforts which are being made by Poland in an endeavour to make full use of the possibilities open to her as a result of the last war.

The Hangchow Bore

By HERBERT CHATLEY, D.Sc. (Engineering), M.I.C.E.*

One of the most striking phenomena associated with the tides is the bore, or eagre, and the best known example of it occurs in China, midway between Kanpu and Hangchow. It may even explain why Kanpu was the landing port for Hangchow, since the bore greatly interferes with the passage of junks into the Ch'ien T'ang river, on which Hangchow lies. Kanpu is now an empty shell, having been destroyed in the Taiping rebellion. It closely adjoins the shore and is connected to the Grand Canal. The Hangchow railway and the proximity to Chapu have probably prevented its revival.

The normal behaviour of tides is, of course, a rise, slow at first, fastest at mid-sea level and diminishing to high water, and then a fall returning to about the original low level. The rise takes six hours or less and the fall six hours or more, the total cycle occupying about 12 hours and 25 minutes. The rise is greatest on the 3rd day of the moon and the 18th day of the moon, and least on the 10th and 25th days. The interval of 12 hours and 25 minutes is that between successive passages of the moon across the meridian, one above the horizon in the south and the other below the horizon in the north. Speaking roughly, this statement applies universally, but the range of the tide and the interval between the moon's meridian passage and high water varies from place to place. There are, however, some places with marked peculiarities. Thus at Chinwang Tao, in North China, there may be sometimes only one high water in 24 hours and 50 minutes, and at Southampton there may be four high waters in the day. Again, as we proceed up a tidal river such as the Yangtze or the Thames, the period of rise shortens and the period of fall increases. The extreme example of this is the "bore," in which the first half of the rise is almost instantaneous.

After this "instantaneous" rise, there is a further ascent which may take an hour or less, a slow rise for three hours or more, and then a fairly gradual descent back to the original low level. It is most noticeable on the spring tides of the 3rd and 18th day of the moon and may not be perceptible at neap tides (10th and 25th of the moon). It also depends on the wind and barometer, so that in the Ch'ien T'ang the 18th of the 8th moon (October) is thought to be the best time for it. In fact, most spring tides give much the same effect.

The only other large bore is in the northern mouth of the Amazon, but there are quite interesting examples on the Hoogli, Sittang and the Severn, and minor bores are to be seen in many rivers. In the model of the Severn, made by Professor Gibson some years ago for the purpose of studying the power possibilities of the Severn tide, the bore is quite well reproduced.

* Excerpts from Lecture delivered to the China Society in Dec., 1948. Reproduced by permission.

Hangchow Bore—continued

An analogous phenomenon to the bore may be seen on a flat, smooth beach. As the wind-produced " swell " comes in and reaches shallow water, the wave " breaks " and forms a comparatively abrupt front which closely resembles the bore. The periodic time of an ocean swell rarely exceeds 20 seconds and may be much less than this, so that the effect is that of a series of bores or lines of surf, but the comparison is mechanically quite justifiable even though theory draws some distinctions between a bore and breaker.

In both cases it will be found that the " break " occurs when the depth of water is of the same order as the total rise of the wave.

Now the rise of the wave depends on a number of peculiar circumstances. In the case of wind waves, the strength of the wind, the stretch of sea over which it blows and the duration of the wind all play a part, but in the case of tides the rise and fall depend on the position of the sun and moon in the sky, the latitude of the place on the earth, the shape of the adjacent shore lines and, most importantly, the depth of the water. In the open ocean, the rise rarely exceeds 3 feet; in closed seas, such as the Mediterranean, it is still smaller; in lakes it is inappreciable; but in shallow seas it is often 10 feet or so, and in narrow converging gulfs it may be as much as 100 feet. It used to be thought that there was one tidal master wave which formed in the Antarctic Ocean and all other tidal waves came from it, but in recent years, owing to the work of Proudman and Doodson, it is realised that tides are produced locally and vary in magnitude by reason of their oscillation agreeing more or less with the natural swinging time of masses of water between certain limits. When there is good agreement, the tidal range may be large, but not otherwise.

In the Yellow Sea and China Sea the tidal rise and fall changes considerably, but off the mouth of the Yangtze and Hangchow Bay a spring tidal range of about 12 feet occurs. At the head of the Hangchow Bay, in the neighbourhood of Rambler Island, near Kanpu, this is greatly increased and may amount to some 96 feet or so, resembling in this respect Avonmouth on the Severn, where even 40 feet can occur. In both cases the estuary converges and, as it converges, the tidal range increases.

Speaking broadly, the reversible currents or tidal streams which accompany tidal changes of level, increase with the range but decrease with the depth. The velocity with which the tidal *wave* (not the water) travels is affected by the depth, but when the latter is comparable with the range, it can happen that the slope of the water surface is very great indeed.

Water surfaces of great slope are generally unstable and a " break " comparable to that of a wave occurs, but without the rotation or curl over which characterises the latter.

In school books the tide is presented as a hump of water which rises on both sides of the earth under the moon (and sun), but in fact, whilst there is a tendency for this to happen—due to the slight lightening of the water by the differential attraction of the moon (or sun) on the water as compared with the earth as a whole—the prime effect of this attraction is a tangential pull on the water at points well away from those under the moon (or sun). Even so, the currents produced are comparatively small and will not account for the tides as they actually are unless we take into account the possibility of a swinging movement of the water. Thus, in a gulf such as the Hangchow Bay up to the sharp turn at Zakow, there is a natural period of swing, determined by the length of the bay and depth of the water. As this coincides with the tidal period, the swinging movement will be greatly enhanced.

Another factor that plays a part is the fresh water run off from the river, which checks the inward movement of the wave. Furthermore, the friction of the bottom causes much of the energy of motion to be converted from a simple stream flow into rotating turbulence, which eventually changes to heat and can never be changed back. On this account the outward or ebb flow is always less active than the inward or flood flow, the tides in shallow water thus rob the earth of a little of its rotational energy, so that the day is gradually growing longer.

The theory of the bore is discussed very fully in Doodson and Warburg's " Admiralty Manual of Tides " (1941), Allen's " Scale Models in Hydraulic Engineering " (1947), and other books. Amongst the ancients, tides do not receive much notice, probably because they are small and irregular in the Mediterranean. Homer seems to refer to a frequent ebb and flow in the Straits of Messina, and Herodotus notices a daily ebb and flow in the Gulf of Suez. Pytheus (330 B.C.) relates tides to the moon. Seleucus and Posidonius are quoted by Strabo and Pliny as having described tides in the Atlantic (Cadiz) and the Persian Gulf and recorded their dependence upon the moon in considerable detail. Quintus Curtius, in his history of Alexander, mentions a strong tidal wave in the mouth of the Indus, and it seems probable that the regularity of tides was first realised by those in Alexander's expeditionary force. Cæsar (book IV) reports full moon tides in the English Channel, as a novelty to his troops.

Professor Moule (T'oung Pao, July 1923) indicates Chinese references to the bore back to 211 B.C. and perhaps 483 B.C., and quotes Mei Sheng's " Ch'i Fa " (about 150 B.C.) concerning a bore on the River Ch'u, which " will be visited at full moon in the eighth month ". The fact that it was expected on this date seems to show that its lunar relation was already known. However, this may be, the well known Taoist philosopher, Ko Hung (4th century A.D.), states clearly that the tides depend on the moon, although he incorrectly says that they wax and wane with it. " The influence of the moon produces water, so when the moon is full the tide is large." He also notices there are two tides a day. The earliest treatises on tides appear to be that of Shu-meng (A.D. 770) and that of Yen Su (A.D. 1020), " Hai Ch'ao T'u Lun " (Ocean Tides illustrated and discussed). Yen Su is well known for his interest in mechanical devices. Both Ko Hung and Yen Su lived in the neighbourhood of Hangchow (Moule, p. 141 and p. 169). The principal Chinese work on tides is the " Hai Ch'ao Chi Shuch," by Yu Ssu-Ch'ien of Haining (1781 A.D.). In spite of its late date, it does not appear to have been influenced by western knowledge.

Prior to the knowledge of the laws of gravity, the cause of lunar influence on the tides led to much speculation. Both in China and Greece there was a tendency to regard it as a sign of the life of the universe showing as a breath or pulse.

The dependence of the tides upon the moon (and the sun) is unquestionable. After due allowance has been made for wind and air pressure effects, the range of the tide is seen to fluctuate with the distance of the moon from the sun, being greatest about two days after the sun and moon are together (new moon) or opposed (full moon). High water and low water occur at fixed times after the moon souths. When the moon is nearest, once a month at gradually changing day in the month, the tides are larger. When it is farthest, again once a month, the tides are smaller. The difference between day and night tides grows and shrinks with the deviation of the moon (and sun) from the celestial equator. Tides are predictable with moderate accuracy from the predictable positions of the moon (and sun).

The popularly believed dependence of the weather on the moon is quite another matter. Rain, wind, deviation of temperature from the normal, cloudiness, air pressure, do *not* change regularly with the pattern of the moon with regard to the sun, or with its declination or distance. Very delicate measurements show minute air pressure and electrical differences which do depend on the moon, but they are so small that they are overwhelmed by changes due to other causes. Weather is not predictable from a knowledge of the moon's position at all, and no meteorologist of repute dreams of employing that method, which has proved utterly fallacious.

The common idea held by many sailors, farmers and others, that the weather changes with the moon's changes is just a bit of superstition. The weather (by which they generally mean wind or rain) may change when the moon becomes new or full, but it may equally well not do so and no prophecy can be made from it. In actual fact, the weather change has no regular period at all, but it does pulsate by reason of alternation of cyclonic and anti-cyclonic conditions at irregular intervals. The occasional agreement of these intervals with the lunar period may be the basis of the superstition, but the more probable reason is the uncritical acceptance of ancient astrological ideas.

Tide tables for Lin An (Hangchow) date back to the tenth century and Moule gives one produced in 1056 A.D., which shows

Hangchow Bore—continued

quite correctly that the range is largest on the 1st, 2nd, 3rd and 4th or 16th to 19th of the moon, that tides change from decrease to increase on the 10th or 25th of the moon, that on the 1st or 15th of the moon high water occurs at noon or midnight and shifts each day by 12/15ths of an hour, i.e., 48 minutes.

In actual fact, the time of high water at full and change (new moon) is 1 hour 56 minutes after noon at Kanpu, 2 hrs. 56 mins. at Haining (19 nautical miles upriver from Kanpu), and 4 hrs. 25 mins. at Zakow (Hangchow), 25 miles above Kanpu, so that the old tide tables must have been based on observations taken at Kanpu, or east of that place.

The first accurate description of the Hangchow bore is that of Captain (later Rear Admiral) Usborne Moore, who visited the site in 1888 and 1892. This is abbreviated in Darwin's "Tides" (1898), pp. 60 to 71. These observations showed that after a 23 foot range of tide at Rambler Island (Kanpu), a bore with a 12 foot front was followed by a further rise of 6 feet in the first hour and a total range of about 20 feet. After the passage of the bore, a flood current of ten knots was observed.

In the circumstances this was an excellent survey and would not normally have been supplemented, but it happened in the years 1919-21 that a much more complete record was compiled, with which the writer was associated. At that time the improvement of the access to Shanghai was under consideration and one of the possibilities was a by-passing of the great bar at the mouth of the Yangtze River by a canal with or without a special outer port at the mouth of the canal. Such a canal would necessarily have its entrance in the Hangchow Bay. The latter is quite shallow near its northern shore for many miles from its entrance at Yangtze Cape, and it was necessary to consider places with relatively deep water well to the west. There are three such places: Chin Shan, Chapu and Kanpu. The general regime of tides, currents and silting in the Hangchow Bay was a matter of great importance, and it was decided to make a comprehensive survey of the whole tidal region up to Hangchow. The initiative for this work came from Mr. von Heidenstam, the writer's predecessor as Engineer in Chief to the Whangpoo Conservancy, and the general execution was in the hands of Mr. E. C. Stocker. The writer co-operated in the matter and a report appeared in January, 1921, entitled "The Hydrology of the Hangchow Bay and the Ch'ien Tang Estuary," and was published in Shanghai. Unfortunately, owing to the subsequent troubles in China, this is now out of print, but there are copies in the libraries at the British Museum and the Institution of Civil Engineers. As far as such matters can be, it gives an exhaustive account of the bore.

In this report, which deals with levels, tides, silt, rainfall, currents, etc., over the whole area, detailed surveys of the bore were made in September and October, 1919, and February 3rd and 11th, 1920, between Kanpu and Haining. In the 1920 records there were detailed observations at six intermediate stations three or four miles apart, and tide readings were taken during the most rapid changes at intervals of one minute, so that accurate profiles of the water surface were obtained. During the slower changes, ten minute intervals were used. The depth of the water below mean level at which the bore commenced to appear was about 16 feet. The vertical front at spring tides was about 10 feet, with a total range of 20 feet, and at neap tides about 5 feet with a range of 16-ft.

Simultaneous tide observations were taken right out to sea and upstream as far as Hangchow. The speed of the waves where the bore commences was about 7 knots at springs and 4 knots at neaps, but was very much faster when it was fully established near Haining. Some most impressive phenomena occur when the bore is generated at two points and the wave fronts intersect and combine. In this case, it may happen that a standing wave of perhaps 30 feet high develops. If it happens near the shore, it may even overtop the very massive sea walls. The noise of the wave is heard quite a time before the bore arrives, so that the whole affair is quite theatrical. After the wave has passed, junks proceed upstream, carried by the strong current and with little or no control.

A feature which is of general interest is the sheltered shelf off the left bank at about half tide level, on which down-going junks are berthed until the bore arrives. This is sufficiently high to ensure that these vessels will not float until some seconds after the bore has passed.

The silt content of the water at the bore front may rise nearly ten per cent. of the weight of the water, but goes back to one-quarter per cent. or less within less than ten minutes.

One feature of the report that must be emphasised is that true levels are incorporated, and not the usual references to mean sea level or low water, so that the data obtained are amenable to treatment by hydraulic theory.

The power possibilities of the Hangchow Bay appear to be very similar to those of the Severn, but the foundation conditions are much less favourable. Even in the Severn, the economics of a power project are doubtful and would be more so in the Ch'ien T'ang. The width at high water in the region of the bore is of the order of ten miles. Much of this is sandbank and the low water width is only about a mile with very little depth.

There have been suggestions that at some periods during historic times the bore has not been operative. As the sandbanks have certainly shifted about a great deal, this may be true, but the records are not sufficient to establish the temporary disappearance of the bore as a fact. It is, however, almost certainly true that if the river were to be narrowed by strong sea walls the channel would deepen and the bore would probably cease to exist. The cost of such work would be very large and its economic benefit uncertain.

The rainfall on the catchment area (some 12,000 square geographical miles) is about 60 inches p.a. The effective run off is about 40 inches p.a., or some 50,000 cubic feet per second. The river off Hangchow varies in height by about 30 feet during the year, increasing in extreme cases to about 50 feet. The mean tidal range is only about 2 feet there, the maximum tidal range being about 5 feet. Thus the bore, although it is seen at Hangchow, should not properly bear the name of that place, since the phenomenon has almost died out there. Haining would be a much more suitable place name. Rather paradoxically, it means "Sea repose"!

New Patent for Bucket Dredges

A French engineer, Mons. A. Gentilhomme, has recently patented a new lowermast tumbler for use on bucket dredges (British Patent No. 592, 364). Although designed primarily for use on harbour dredges where the abrasive action of the sand is particularly heavy, it is claimed that the new device reduces wearing of the lower tumbler on any dredge to the absolute minimum.

The lower tumbler on a bucket dredge is usually keyed to a shaft revolving in bearings, and owing to the particular way in which the bucket chain works, these bearings are immersed in water full of solid particles of sand, or mud, which come between the stationary and moving parts and cause considerable wear. For this reason bucket dredges, as now designed, cannot work longer than a few months in sand, after which the worn parts have to be replaced.

M. Gentilhomme's new device clears the abrasive particles by means of oiled air injection. The patented tumbler is quite simple in design and does not require the use of any special grade of steel, a small compressor and oiler of conventional design being fitted to the dredge. If the stresses at the tumbler are correctly determined, it is claimed that the new type of tumbler should last between 20,000 and 30,000 hours.

Erratum

In the Editorial Comment about the American Suction Dredger, which appeared on page 222 in the December issue of this Journal, an unfortunate misprint occurred. It was stated in the second paragraph that "there is an 800 yard hopper, and power is produced on the turbo-generator system." This of course should read, "there is an 8,000 yard hopper, etc."

Suggested Outline for a Canal Transport Policy

By BRIG.-GENERAL SIR H. OSBORNE MANCE
K.B.E., C.B., C.M.G., D.S.O., M.Inst.T.

At a meeting of the Midland Section of the Institute of Transport held in Birmingham on the 6th December last, Brig.-General Sir H. Osborne Mance, the President of the Institute, delivered an address in which he advocated the establishment of a vigorous canal policy conducive to the revival of a strong virile, and economically sound industry.

Commencing his address, Sir Osborne Mance said that he hoped to convince his hearers that, when considering a future canal policy for the United Kingdom, this question not only affected the neglected canal industry or the vested interests of hitherto competing forms of transport, but had important implications in the future planning of trade and industry, in particular in the Birmingham area, and in town and country planning over a much wider region, while offering some contribution to plans for stabilising employment.

The present situation, as far as it might be disclosed, was reviewed by Mr. W. L. Ives, A.M.Inst.T., of the Docks and Inland Waterways Executive, in a paper before the Metropolitan Section on February 7th. Mr. Ives pointed out that the new organisation was faced with three main problems: (1) to establish an organisation; (2) to ensure that current business was carried on smoothly and without interruptions; (3) to give consideration to the future problems, and indicated that the first two objectives having been achieved, the Executive was now free to devote its energies to the third.

Nothing concrete had yet been published on the matter, and he offered the following remarks realising that the Executive, in the light of its researches, might be able to base a policy on more up-to-date information than that at his disposal.

While a few canals paid dividends on their ordinary capital, the financial situation of most of the independent canal undertakings was precarious and only sustained by revenues from ancillary sources—warehousing, rents for land and water and, in some cases, interest on investments. The average rate of return from all sources on the capital expenditure of the independent canals was less than 2 per cent., of which less than one-third came from traffic operation. The Annual Report of the British Transport Commission for 1948 showed that the tolls provided about half the revenue. As regards the carrying side, the independent canal carriers, not being common carriers, could pick and choose their traffic and, if the canals were to be allowed to languish, could earn a living long after the total traffic ceased to yield enough tolls to keep the canals financially in existence. In 1938, the railway-owned canals showed a net loss of £65,000 (excluding certain annuities).

The traffic carried by canals has steadily fallen. At the peak period they carried about 40,000,000 tons a year. This fell to half when the railways reached effective competition. Since then road competition had contributed its share to the fall of canal traffic. This falling off in traffic was also due to the complete disappearance of some of the traffics which used to be the mainstay of the canal industry. Water-side collieries had been worked out, factories closed down, or used for other purposes not requiring coal supplies, and mills had been concentrated at the ports. Many of the smaller electricity stations had been closed down as a result of the grid and factories had changed over from steam to electric power. Quarries had been worked out; the nature of road materials had changed; towns and cities had adopted new methods for the disposal of refuse; iron ore deposits had been worked out leading to the disappearance of heavy industries, and so on.

This fall in traffic, which was accompanied by a continually diminishing proportion carried on the railway canals, was illustrated by the following comparative figures of originating tonnage:

1924	...	16,456,000	1944	...	11,047,000
1938	...	12,952,000	1947	...	10.096.000
1941	...	11,510,000	1948	...	11,231,000

The average haul in 1948 was only 17 miles. The war figures were maintained with great difficulty, chiefly owing to the loss of staff, but also to lack of facilities for the upkeep of both the canals and the craft.

The Wage Question

One of the most important problems overshadowing the canal industry was the wage question. This was not so serious for barges conveying some 100 tons or over, but it constituted a serious menace in the case of long-distance traffic in narrow boats, each carrying from 20 to 30 tons, which alone could work on some 930 miles of canals including the canals leading from the four estuaries to the Birmingham area and the network in that area. Up to 1944, and possibly also now, short-distance traffic in these boats, generally coal traffic, was just able to pay wages in step with comparable industries. Long-distance boats had small cabins in which the crews lived permanently. They were normally either worked singly by a man and his wife using horse traction, or in pairs by a man and wife and young son or daughter. The normal family wage for a pair of boats in 1944 was about £7 per week. Other pairs were worked by two men who have to be real experts. It was true that living costs were low, with no rent, and in the case of Company boats free fuel and light, but amenities were non-existent.

Moreover, the education of the children born and bred to the industry presented a problem which, having regard to the provisions of the Education Act, would be insoluble while the children lived on the boat. If the children were obliged to live ashore, other than in special boarding schools provided near the main canal depots, the mother would follow them and the economic basis of this important branch of the canal business would be undermined, the more so as the children who were the chief and by far the best source of recruits for the industry, after growing up ashore, would be less likely to go back to the canals. Mr. Ives said that a residential hostel was being provided at Birmingham by the local education authority, with the assistance of the Ministry of education, as a first step. Sir Osborne mentioned that the same difficulty about education exists on the Continent.

These problems could probably only be solved by providing employment at a wage which would enable a boatman to have a home on shore, at least during the period when his family were of school age. Such a wage could not be earned on a pair of narrow boats. Unless these conditions were altered, he felt that the narrow-boat canal industry would languish and ultimately be allowed to disappear as a non-economic proposition not worth maintaining in the national interest.

General Considerations

In considering a future policy one could classify canals into three categories:

(1) Waterways which might be expected to pay their way commercially (with or without ancillary revenue) with fair conditions and some encouragement;
(2) Waterways which might not pay their way but whose maintenance and even development were directly or indirectly in the national interest on economic or possibly strategic grounds;
(3) Waterways which should be definitely abandoned, or which can be left outside any official scheme.

The question must be approached from the point of view of the national interest and not merely that of the canals versus other forms of transport, and one must always bear in mind that the main economic objective should be to provide the cheapest and most efficient service of transport for trade and industry.

A policy which had been proposed by the more cautious element of the industry was to be content, at least for some time, with the existing canals, subject to certain improvements such as dredging and walling, and to arrange for railway and road tariffs to be fixed sufficiently high for the canals to be able to offer a differential which would enable them to double their traffic and work at a profit. Failing that it was claimed that the canal tolls should be reduced or subsidised by the Government.

Doubtless the railways were able in the past to charge arbitary rates to compete with inland waterway transport by accepting a lower contribution to overheads while canal overheads were levied in the form of tolls by a separate organisation. In future, how-

Suggested Outline for a Canal Transport Policy—continued

ever, when the rail and canal tracks were maintained by the same financial interest differentials would probably be based on the operating costs of the two means of transport. The only long-term solution was therefore to reduce the cost of canal operation until it was sufficiently below railway costs to justify differential waterway rates. For reasons already explained, improved maintenance only of the existing canals would certainly not reduce the cost of operation of the narrow canals to anything like the extent necessary for waterways to justify their economic existence.

It is necessary therefore to look well ahead and examine a more forward policy designed to serve the public interest by reducing the cost and increasing the efficiency of inland waterway operation. Both the Royal Commission of 1909 and of the Chamberlain Committee of 1920-21 favoured the ultimate reconstruction of the " Cross " linking the four main estuaries with the Birmingham area. Since the dates of these reports the situation had notably changed as a result of the development of road transport which had largely increased the normal delivery radius. This and the fact that many industries which might bring traffic to canals were not now located alongside the waterways, had reduced the importance of extending the arms of " The Cross " to the centres of the industrial Midlands. While inter-connection between the different arms of " The Cross " was perhaps of secondary importance, in view of the competition of coasting services, there might be some important long-distance through traffic, and cross connections would widen the scope of the principal carriers and facilitate the distribution of craft to meet local peaks of traffic besides being of great value in war-time. For these reasons it was necessary to plan ahead for a uniform minimum standard for the improved waterways. During the recent war there was only one barge connection across England—the Leeds and Liverpool Canal—and small craft shipped across England further south had to be carried by road between the available waterway termini. " The Cross " would have been of great value for such a service.

The development of rivers for navigation has great advantages over the construction of canals, both because there is no difficulty as regards water supply and because the rise from the coast is continuous, involving few locks, whereas canals are frequently carried over intervening summits involving a greater number of locks and water difficulties. For these reasons the most promising schemes were those for the development of the Severn and Trent routes to serve terminal depots within easy reach of delivery by road to the centre of England.

Need for Standard Craft

In considering what improvements should be made to selected inland waterways it was necessary to decide what should be the standard craft for which provision should be made. This involved many considerations. Such a craft should be able to work efficiently both in the estuaries and docks and also in still-water canals, with particular reference to the advantages of direct ship-to-destination transport to any point on the system. The capacity should be the maximum in relation to the size of the crew. The units should be the most convenient size for the trade of the country. The best relations of length, beam, draft, and headroom of craft must be worked out having regard to the relative operating advantages and to the engineering costs involved in the construction or improvement of the waterways. The influence on the above factors of working craft in pairs or larger tows should be carefully considered.

The subject was investigated in some detail during the war by a committee of engineering and operating experts who recommended that detailed designs and experiments should be based on the following dimensions:

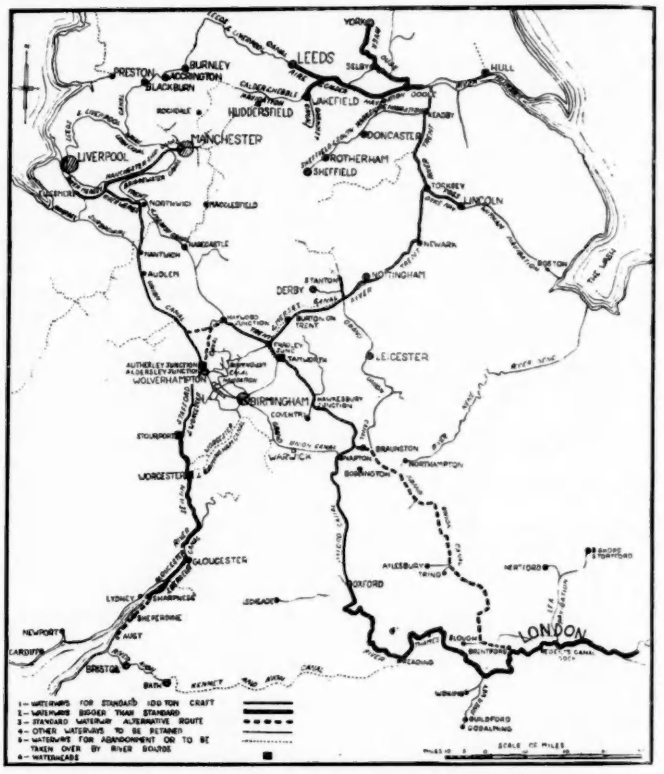
Length, 92-ft.; beam, 14-ft. 8-in.; draught, 5-ft.; headroom to pass under 10-ft. 6-in. bridge.

The carrying capacity of a motor craft of these dimensions would probably be about 100 tons of average cargo. That of a dumb craft the same size would probably be about 120 tons. For estuarial work the vessel should be capable of loading to 5-ft. 6-in. draught. Locks should provide for working at least pairs of boats. These recommendations were near enough as a basis for preliminary schemes for an improved type of waterway.

The speaker then went on to consider the routes which might be adopted.

Trent

Instead of utilising the route of the Trent and Mersey narrow canal, as suggested by the Royal Commission in 1909, it was proposed that the waterway should follow the Trent up to its junction with the River Tame, and then the Tame up to a waterhead at Tamworth, some 14 miles from Birmingham. This waterhead would be connected at Tamworth to the Birmingham narrow canal system as well as to road and rail. The waterway should take the standard boat and also the existing type of barge now operating between Hull and Nottingham (82-ft. 6-in. by 14-ft. 8-in.), but limited to 5-ft. draught which was, only ocasionally exceeded on



Map showing proposed inland waterways system.

the Trent with normal cargoes. Certain improvements north of Nottingham would be involved, but most of these would have to be carried out in any case.

Severn

A special feature of the Severn Estuary was the number of ports from which traffic could be directed to the Severn Waterway. The sea passage between some of these ports and the Severn involved the use of craft which were too big at present to navigate the river, necessitating a transhipment at Sharpness or Gloucester. To get over this two alternative schemes had been put forward.

A scheme was prepared by Colonel Saner in 1938 for improving the navigation to take 300-ton motor barges to Stourport (some 20 miles from the centre of Birmingham) instead of the present 150-ton barges. An alternative scheme has been suggested to give access for 500-ton coasting vessels to Worcester while continuing the 300-ton barges scheme to Stourport. The main technical problem lay in the provision of the necessary headroom in the Gloucester area.

Mersey

The Royal Commission in 1909 recommended a route following the Weaver Navigation to Northwich and continuing by the Trent and Mersey Canal alignment to Wolverhampton via the Staffordshire and Worcestershire Canal, and to Birmingham via the Fazeley Canal. The scheme for 100-ton horse-drawn barges was estimated

Suggested Outline for a Canal Transport Policy—continued

to cost (at 1909 prices) £2,559,541 for the canal to Birmingham and £486,255 for the branch to Wolverhampton. This route had the advantage of serving the Potteries area, but had the disadvantage of the intermediate Harecastle Summit with its water problems which were to be solved by the use of inclined lifts. Moreover the cost of improving the canal through an industrial area and of rebuilding the Harecastle tunnel would be heavy.

In 1925 Colonel Saner, jointly with Mr. Humphries, City Engineer of Birmingham, presented an alternative scheme with an alignment leaving the Weaver Navigation at Old Bridge above Northwich and proceeding partly by a new route and partly by the Trent and Mersey route to Aldersley Junction and thence via Wolverhampton to Birmingham. The scheme for 100-ton barges was to cost **£6,593,627** at 1925 prices.

In 1943 Colonel Saner proposed a different alignment following the Weaver to Nantwich and then by a new canal to Autherley Junction at the head of the Shropshire Union Canal and at the foot of the Wolverhampton plateau. The revised estimated cost of this scheme, including land purchase was **£4,000,000**. Only four new lifts were proposed between the Weather and Autherley Junction as compared with twelve and eleven respectively besides locks in the earlier schemes. The earth work would be heavy and the route would involve considerable land acquisition and severance of property. It would, however, have the merit of being designed at the outset for a 100-ton craft.

An alternative had been proposed of following the Weaver to Audlem on the Shropshire Union Canal and then following the Shropshire Union Canal route to Autherley Junction, all the existing locks, except one, being replaced by lifts. The scheme would pass through agricultural country with little intermediate traffic offering at present en route. It would, however, present less difficulty as regards the acquisition and severance of property as regards road and rail crossings. A preliminary estimate of the Audlem scheme amounted to 2½ million pounds at 1943 prices, to which should be added say, **£250,000** for the water head near Autherley Junction.

On the information available, he was inclined to recommend the last of these schemes, with its spacious water head at Autherley Junction.

Thames

The chief canal access from the Thames to Birmingham is by the Grand Union Canal. This was at present a narrow-boat canal, but with locks capable of taking two boats at a time, and an available draught of not more than 3-ft. 9-in. It had been proposed to widen the canal and deepen if for 4-ft. 6-in. draught vessels so as to take motor barges of 70 tons capacity or a pair of enlarged narrow boats of about the same combined capacity.

Owing to the existence of two summits of 391-ft. and 359-ft. there were 153 locks between the Thames and Birmingham. An even more serious disadvantage of this route was the shortage of water which might well prove to be an insuperable obstacle to the operation of a barge canal of the minimum capacity which should be provided for. While the 70-ton barge could work on the Thames, which the narrow boats cannot, but the adoption of a smaller craft than that which would be standard for the rest of England would be a fatal objection in a national scheme, apart from the probability that a craft of this size would not fulfil the conditions referred to above for an economic wage structure. Even if the water difficulty could be surmounted the conversion of the canal to take the future standard craft would involve the reconstruction of the long Braunston Tunnel and the rebuilding of every lock, and presented so serious a problem that any possibility of an alternative route must be carefully investigated. Such a route, 55 miles longer, existed via the Thames to Oxford, and by an enlarged Oxford Canal to meet the Grand Union route at Napton. Owing to the higher speed possible on the river and to the saving of 31 locks due to the avoidance of the Tring Summit, the time of the through passage would be approximately the same by either route, though it was understood that there might be difficulty in navigating the Thames in time of high flood.

The present Oxford Canal was a narrow-boat canal with single locks. It would have to be reconstructed with frequent re-alignments to make it serviceable for the standard craft. The only alteration necessary on the Thames below Oxford would be the deepening of the sills of five locks by a few inches. A more serious difficulty would be the reconstruction of, or a diversion round, Osney Bridge at Oxford, to obtain the necessary head room. By limiting industrial development to the important existing centres of Reading and Oxford, the amenities of the River Thames would not be unduly impaired. The water supply for the Oxford Canal would be easier to arrange than in the case of the Grand Union, especially if arrangements could be made to borrow water from the Cherwell for pumping to the summit, to supplement the existing supplies if the canal is worked to capacity in dry weather.

The cost of the Thames arm of the standard boat " Cross " might be heavy compared with that of the other arms, but this would have to be faced to round off a national scheme.

Communicating Routes

As regards communicating routes between the arms of " The Cross," the enlargement of the Thames branch would involve a corresponding extension over the northern part of the Oxford Canal and the Coventry Canal, to give access by the larger craft to the coal fields. This access would provide the greater part of the future connection between the Thames arm and the Trent arm at the Tamworth water head, which would also be the water head for the Thames branch, the section Napton-Birmingham of the Grand Union remaining in its present state.

Connection between the Severn and Mersey systems could be obtained by an improved Staffordshire and Worcestershire Canal as proposed by the Royal Commission, while the Mersey and Trent systems would ultimately be connected by a link on the Trent and Mersey alignment between Haywood Junction and the River Trent near Fradley Junction. No direct connection between the Severn and the Grand Union was recommended. The Worcester and Birmingham Canal route, 30 miles long (at present, with 58 single narrow-boat locks) recommended by the Royal Commission as such a connection, should be abandoned now that the delivery from the Severn was being made by road transport from the newly-constructed water heads at Worcester and Stourport. The connection from the Grand Union via Leicester to the Trent could be left to a later stage as it was less important and there were water difficulties.

In normal conditions the execution of the plan could be spread over a number of years, but the time would come, sooner or later, when it would be necessary to apply a corrective to a sag in employment by timed investments including the execution of public works. Preference would naturally be given to schemes which were productive, i.e., which could earn the interest and amortisation of the capital cost, but this was not essential, and it was now generally conceded that in the interests of the maintenance of full employment the State would be justified, particularly during periods of bad trade or in areas affected by depression, in promoting capital works which would not otherwise be considered economic. The most suitable works for this purpose were those which could be quickly started and brought to the peak of the employment involved, and which could be completed within a period of two or three years so as to avoid overlapping and accentuating any subsequent period of comparative boom. From this point of view canal construction in this country would be ideal, as work could be started at numerous points simultaneously and the scheme divided into convenient sections.

It is essential that the detailed schemes should be prepared beforehand and the necessary parliamentary powers obtained in normal times, so that any or all the schemes could be put in hand immediately a decision is reached to finance them.

The necessary engineering surveys to supplement those already carried out would fulfil the double purpose of preparing a detailed scheme for a final decision as to the future canal policy and of preparing the ground for the execution of the works as part of the full employment policy of the Government. If the Inland Waterways Executive had its schemes ready it might be that it would get away with the finance ahead of other authorities whose schemes were not so ready.

Suggested Outline for a Canal Transport Policy—continued

Co-Ordination of Planning

There was, however, another aspect of urgent importance. If it was decided to adopt the kind of policy suggested, it was most necessary that the details should be made known as early as possible to all the other planning authorities likely to be affected, such as the road authorities. In this country the cost of rail and road crossings constituted a substantial part of the total cost of canal construction. If the future canal system could be made known with full details of alignment and levels, the road authorities could be warned that any highway crossing the alignment must provide for a bridge of suitable dimensions, or the possibility of constructing one. This would be much easier to arrange in the planning stage of a highway than at some future date when very expensive alterations might be involved. With detailed proposals before them the different authorities could examine the effect of the canal scheme on their interests and at the planning stage mutual adjustments could be made to overcome particular difficulties. It would further be important that land on an adequate scale should be reserved, under town planning schemes, for development of the water heads and associated factory sites.

Operating Efficiency

Serious research was also necessary on the best means of reducing operating costs. Waterways were under a disadvantage compared with railways and roads in that cargoes had to be lifted from holds for delivery or transhipment. In the case of coal the laborious shovelling at small distributing centres is replaced by cranes and grabs at the more important works. It is worth studying whether a further saving would not be effected by the use of containers, with the advantage of reducing the unloading time from hours to minutes. The users would have to play their part in improving terminal facilities. In this question each item of traffic would have to be considered separately, including cases where containers would effect economies when used in conjunction with rail, road or even sea transport.

It was most important, both in considering policy and in determining the best division of traffic on a nationalised transport system, that there should be detailed research as to the cost of working on inland waterways, a subject on which there had been very little information in the past. Such research would well repay the comparatively small effort involved, and in fact the few thousand pounds involved in the surveys and enquiries already recommended would be quite negligible compared with the advantage of a well thought-out policy and the avoidance of waste in the carrying out of approved schemes.

Need for Decision Now

In conclusion, Sir Osborne said that he wished to emphasise the urgency of these investigations and of a decision now on future canal policy. He could not conceive the existing narrow canal policy. He could not conceive the existing narrow canal system being maintained except at a cost to the State out of proportion to its utility to the nation. The alternative would therefore seem to lie between the abandonment of any idea of an inter-connected national waterway system on the one hand and a vigorous canal policy on the other, conducive to the revival of a strong and enthusiastic canal industry. Personally, he thought the second alternative was the best policy in the national interest.

Notable Port Personalities

No. LXI—Mr. Arthur H. Abel

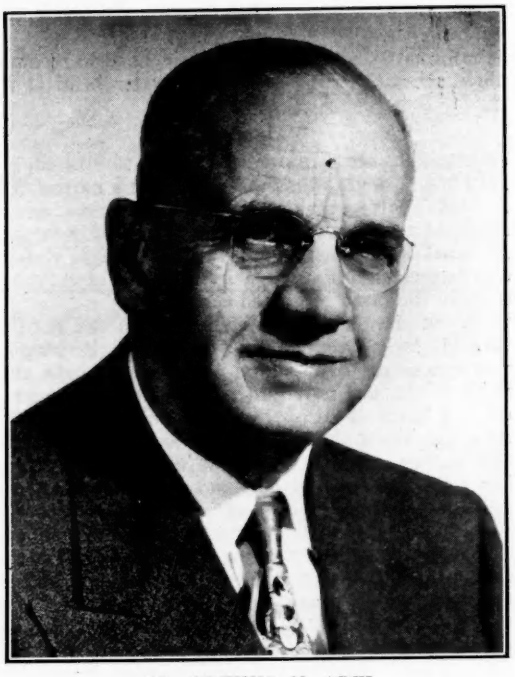
We are pleased to include in our list of Notable Port Personalities Mr. Arthur H. Abel, who has succeeded Mr. Harry C. Brockel, of Milwaukee, as President of the American Association of Port Authorities. The thirty-eighth annual convention of the organization was held at Milwaukee, Wisconsin, during October last, and in his speech of acceptance, the newly elected President said he was proud to bring the Presidency of the influential North American Port Assn. back to the Pacific Coast and to Oakland.

Mr. Abel, who is Port Manager and Chief Engineer of the Port of Oakland, California, has been with that Port continuously since its inception in 1926. He was born in Walla Walla, Washington, and was educated at Spokane, Washington, and later graduated with a civil engineering degree from Washington State College. He entered the engineering profession by engaging in railroad surveying and construction work for the Hill system and the Northern Pacific in the Northwestern States.

In 1908 he entered private engineering practice in Portland, Oregon, with the late G. B. Hegardt, engaging in general civil engineering, including construction, irrigation, dredging, etc. In 1910, they transferred to the newly formed Commission of Public Docks in Portland, Oregon, and started the construction of the port facilities there. Mr. Abel's first assignment was as assistant to Mr. Hegardt, who filled the position of Chief Engineer and Port Manager for Portland. He remained in that position from 1910 to 1926, during which period they directed the operation of the port and carried through to completion a ten million dollar harbour development plan.

When it was decided to form the Port of Oakland and the Oakland Board of Port Commissioners to operate and administer the municipal harbour facilities, Hegardt and Abel were made responsible for the development programme which was started early in 1926. The two men carried out the major engineering works which resulted in the construction of the Outer Harbour Terminal, the Grove Street Terminal, Ninth Avenue Terminal, the Oakland Municipal Airport, and other Oakland harbour developments. The two men were responsible for the integrated programme of development which has guided the construction of the Port since that date, and which is still the blueprint for the Port's further development in the future.

Mr. Hegardt retired as Port Manager and Chief Engineer in 1932, and Mr. Abel was immediately appointed to succeed him, and has guided the administrative, engineering, and operational destinies of the Port of Oakland and the Oakland Municipal Airport under the direction of the Oakland Board of Port Commissioners continuously since that time.



MR. ARTHUR H. ABEL
President American Association of Port Authorities.

As a result of his outstanding work in Portland and Oakland, Mr. Abel has a national reputation as a port engineer and administrator, and is frequently called upon for technical advice. He was President of the Pacific Coast Association of Port Authorities in 1939, and President of the California Association of Port Authorities in 1943.

Quay Lay-out

Problems concerning Sheds, Equipment, and Transport of Cargo

By HERMAN JANSSON
(Chief Engineer, Stockholm Harbour Board.)

Introduction

THE primary task of a commercial harbour is to be the reloading place between sea and land transport, and to make the speedy loading and unloading of vessels possible. The planning and equipping of a quay with cranes, railway lines, roads and buildings for the storage of cargoes is, therefore, dependent on the nature of the freight and on the means of transport by which it is brought into, or taken out of, the harbour.

In bulk cargo harbours, the volume of the freight is so great that each type of cargo can have its own berth, specially fitted out for receiving, handling, storing and forwarding the cargo in question. Quay lay-out in such harbours may be determined on definite and detailed lines which are known for every special case.

In general cargo harbours, on the other hand, this is not the case. Freight of every conceivable kind is handled there, generally in small consignments. Only in certain cases does the quantity increase sufficiently for special storage accommodation or transport arrangements to be made. In the great ports of the world, such as London, much freight which is treated as general cargo in Swedish harbours is handled in such large quantities that it may be advantageous to have specially equipped berths.

The difficulty of determining how the quay shall be laid out and equipped in a Swedish general cargo harbour is that the composition of the cargoes arriving and departing is not known, but varies from case to case. The cargoes consist of a variety of different sorts of freight in crates, sacks, barrels, etc., and of bulky articles and freight of great length such as pipes, beams, steel section, etc. Some of the freight is susceptible to the weather and must be stored under cover, some may be stacked in the open.

Imports are distributed to a great many recipients, and no sorting can be done in the hold during discharging because the goods there are usually mixed together. Sorting must therefore be done on the apron, preferably during or immediately after discharge.

Since the end of the second world war, conditions in the larger Swedish general cargo ports have undergone a change, because a large part of the European traffic has been replaced by trans-oceanic traffic. In the latter, cargoes are considerably larger, and the necessity for the quickest turn-around possible has been intensified because of the value of the tonnage. Cargoes of 5,000 tons divided into 50,000 to 60,000 packages have thus occurred.

In extending Swedish general cargo harbours, regard should be paid to the increased importance of this trans-oceanic general cargo traffic and to the present uncertainty about the future proportions between European and trans-ocean traffic. With this in mind, quays should be given sufficient depth to enable ocean-going vessels to berth, and harbours should in other respects be equipped to handle both European and trans-ocean traffic.

In addition, quay lay-out should be such that certain loading can be carried out in berths which are primarily intended for unloading, because the big ocean-going ships on fixed routes are not easily shifted, and are so large that they can often be loaded and unloaded simultaneously.

The design and equipment of the quay in general will be dependent upon what means of transport the harbour should mainly serve and upon to what extent direct loading from land transport to vessel and vice versa shall be done. For example, should such direct loading not occur at all, or only to a very limited degree, then storage space must be found for the whole of the cargo. On the other hand, no roadways or rail tracks need be extended to within reach of the quay cranes or ship's derricks. The piers at Manhattan, in New York, form a good example of this type of quay lay-out.

Another factor which affects the determination of the quay lay-out to a considerable extent is whether the harbour is equipped with cranes, so that all loading and discharging of cargoes is crane operated, or whether they must be carried out, either entirely, or in part, by means of the vessel's own deck cranes and derricks. The reach of the quay cranes has, naturally, a big influence on how the quay area shall be arranged.

Modern European general cargo harbours have usually generous crane equipment, often with wide reach, while in American harbours, vessels must often load and discharge with their own derricks, possibly in conjunction with lift devices set on the sheds.

The desire to have one, two or three railway tracks along the quay side for direct loading may have been the deciding factor for those European harbours with quay cranes. In this way, manual labour is saved in comparison with derricks. Cranes have also reached a high degree of efficiency and suitability to various circumstances. The modern rotating level-luffing crane has great capacity and reach, and is therefore particularly suitable for general cargo work.

After the war, however, both the cost and the delivery time for quay cranes has increased so much, that it has become doubtful whether the equipment of a general cargo harbour with the number of cranes that the quick turn-around of a vessel demands is economically defensible. The same result can be achieved by the use of the vessel's derricks, but more man-power must then be used than with cranes. With derricks, however, one cannot unload the cargo at any distance from the water's edge, and direct loading vessel-railway wagon or vice versa can only be done from tracks laid right close to the edge of the quay. Neither can the upper floors of the sheds or warehouses be reached by this method. The use of derricks limits the shed to one floor, or possibly two if it is very close to the quay edge.

It may not be suitable, therefore, to base the unloading of a large vessel in a modern harbour on simply the use of the ship's derricks, unless the quay apron and its transit sheds are arranged on one plane, and unless there are efficient means for transporting the unloaded freight from this plane to places at a greater distance from the quay. During the war, such means of transport (dock trucks and truck trailer trains) had been developed in America and have reached a high degree of efficiency. A fork truck, which has as large a capacity as a modern general cargo quay crane within a transporting distance of 100 metres, costs only about 5—10% of the price of a quay crane. The purchasing of horizontal plane transport equipment is, therefore, no great economic problem when one realises that the cost of modern crane equipment usually composes about 10—20% of the total cost of fitting out a harbour. If it should be possible to dispense with the greater part of the expensive crane equipment by purchasing modern horizontal transport gear, it would be a very welcome drop in capital outlay for the harbour. The question arises, however, of whether the saving on capital outlay would be consumed by the increased working costs due to the necessity of employing more man-power for loading and discharging cargoes with derricks and mechanical horizontal transport than with cranes with a big reach. In those cases where the reach of the quay crane would not be sufficiently large to place the freight in the desired position without resorting to the use of mechanical horizontal plane transport, it is not improbable that unloading with the vessel's own derricks would be more economical. How the relationship really stands, however, cannot be decided without thorough-going studies into the work-processes in each separate case.

The necessity for, and suitability of, quay cranes in a general cargo harbour will depend, then, on whether more than one rail-

Quay Lay-out—continued

way track is desired alongside the water's edge. If it is considered that direct loading is so important that two or three tracks are necessary, quay cranes must be provided which have a sufficiently large reach to load and unload the railway wagons and also to enable freight to be placed beyond these railway tracks for storage or transport by vehicles.

In large Swedish general cargo harbours, good railway communications are usually required up to the quay side. When extension or new construction is necessary, this should, therefore, be crane equipped.

The high cost of procuring quay cranes in comparison with other means of transport renders it vital, however, to investigate whether they cannot be dispensed with, provided that the harbour has adequate horizontal plane transport. The generous provision of cranes and derricks of a modern vessel should then be capable of handling the lifting of the cargo between the hold and the quay side near the vessel to a greater extent than is at present done in most Swedish harbours. Such an examination can not be made otherwise than by undertaking practical comparative tests in suitably situated harbours.

It may be asked, however, whether sufficient value can be attached to tests carried out in a harbour laid out for quay cranes, as the quay area might possibly be arranged in a quite different way, and the sheds differently situated, to make efficient use of modern horizontal plane transport. It might be best, therefore, to consider, even at this early stage, how the apron and sheds should be designed for loading and unloading with ship's derricks and horizontal transport. For the sake of comparison, the arrangement of a general cargo harbour designed for quay cranes in accordance with the latest practice should also be given.

The determination of the quay lay-out in a general cargo harbour according to the arguments advanced so far, depends on whether the harbour shall be equipped with:

1. Quay cranes, when the following cases may be considered:
   (a) An apron with either no railway track, or only one, running close to the edge of the quay, with a shed of one or more floors.
   (b) An apron with at least two railway tracks, close to the edge of the quay, and a shed of one or more floors.
   (c) An apron on two levels with a shed of one or more floors.

2. Exclusively mechanical means of horizontal plane transport for shifting freight on the apron from side of the vessel. No cranes, and all loading and unloading done by the vessel's own derricks and cranes.

1. A HARBOUR EQUIPPED WITH CRANES

The modern general cargo cranes are level luffing cranes, designed for loads of from 1.5 to 5 tons. Reach should be as large as possible, though not so much as to make the design clumsy. Speed and efficiency of working must be kept. A maximum reach of 25 metres radius has proved satisfactory for the smallest lift, 1.5 tons. The axis of rotation of the crane head should be situated

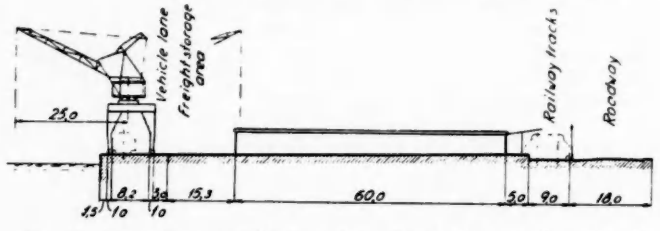


Fig. 1. Quay lay-out with one railway track close to the edge of the quay and with one-storey shed.

sufficiently far back from the edge of the quay to ensure that the rear portion of the head remains at least one metre within the edge of the quay when the jib is pointing away from the water. If this axis is 6 to 6.5 metres from the edge of the quay, this condition should be fulfilled. A maximum radius of reach of 16 to 16.5 metres should be set for the 5-ton lift so that the crane can place loads to a distance of approximately 10 metres beyond the edge of the quay, i.e., to the centre line of a vessel moored alongside which has a beam of 20 metres. The rotating luffing crane may be placed on a movable gantry or semi-gantry spanning the railway tracks laid close to the edge of the quay and any possible roadway located there also. Whether the crane should be mounted on a full or semi-gantry will depend to a certain extent upon the size of the vessels which will be served (weather deck height above the dock of the quay) and upon the nature of the cargoes to be

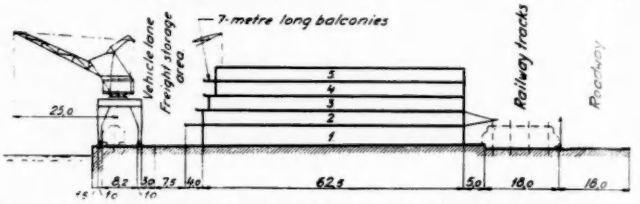


Fig. 2. Quay lay-out with one railway track close to the edge of the quay and with a five-storey shed.

handled. With a semi-gantry, with its high rear track, the apron between the crane rails will be more accessible to vehicles, and the area along or under the rear travel rail of the crane can be better utilised for storing freight. Freight which shall be placed on the apron behind the crane track, however, must then be lifted over it, which may be troublesome when handling lengthy articles such as pipes, beams, steel section, etc. When loading and unloading large vessels, the cargo must, in any case, be lifted high to reach the ship's hatches, and a high lift is then of less importance.

Full-gantry cranes shut off the area between the crane travel rails from the rest of the apron when many cranes have to be placed close to each other to unload a large vessel. A space on the apron of about 2 metres breadth around the rear crane rails must always be kept clear of freight so that the movement of the gantry shall in no circumstances obstruct the movement of freight.

Full-gantry cranes should prove most suitable on an open apron in unloading heavy and bulky freight from medium-sized vessels. If the apron has a shed, the rear crane rail can usually be sited elevated and in the same line as the front of the shed, which takes up a large portion of the total length of the berth, thus offering less obstruction to the movement of vehicles and freight and its storage, than if the rear crane rail was on the deck of the quay.

The span of the gantry is usually taken to traverse either one railway track for smaller cranes or one railway track and one roadway, or two or three railway tracks for larger ones.

The siting of the railway tracks in relation to the roadways may also be discussed. Working from the outside of the quay, the following cases may be considered:

(a) Crane rail, one railway track and one vehicle lane, or just two railway tracks, crane rail, two railway tracks.
(b) Crane rail, two or three railway tracks, crane rail, vehicle lane.

In the former case, one railway track and one vehicle lane will lie beneath the gantry, while two railway tracks will be in the open behind the crane. In the latter, the railway tracks run between the legs of the gantry and the roadway lies behind them. This is the arrangement usually to be found. As railway wagons on tracks situated behind the gantries are more easily accessible when the cranes have to be placed close to each other, this arrangement may be preferred when direct loading wagon—vessel or vice versa shall be carried out at high pressure with the wagons coupled together into complete trains.

With quay cranes of the above type, the quay lay-out might be determined in the following manner in instances 1a, 1b, and 1c.

1 (a) An Apron with either no railway tracks, or one laid close to the edge of the quay, and with a shed of one or more floors. (Figs. 1 and 2).

An apron with a maximum of one railway track, laid close to the edge of the quay, means that direct loading cannot be carried out to any great extent. Loading and unloading making use of

Quay Lay-out—continued

vehicles must, therefore, be presumed to be the method mainly used, and generous free space should therefore be maintained within the working area of the crane. In front of the sheds, there should be space for one railway track and a double row of vehicles, one lane for loading and unloading, and the other for the passage of traffic. These lanes take up an effective width of 6 metres. The working area of the crane should be encroached upon as little as possible by the sheds, as the reception of freight directly into them through a trap door or hatch has not proved to be practicable in our relatively cold and damp climate.

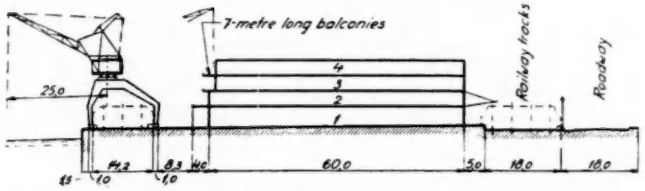


Fig. 3. Quay lay-out with three railway tracks close to the edge of the quay and with a four-storey shed.

It should be possible to place the freight in front of the doors of the sheds by cranes, but not nearer the walls than about 2 metres. The transport along the quay of the freight to be taken into the sheds is thereby avoided. Assuming a crane spacing of 20 to 25 metres (centre to centre), for unloading a large vessel, each crane should be able to place its load anywhere in front of the sheds on this stretch. In a circle of 25 metres, the chord is 23.6 metres long with a pitch of 3 metres.

The wall of the shed should thus be situated about 25—3+2=24 metres from the centre line of the cranes. As this centre line for the type of crane assumed was 6 to 6.5 metres from the edge of the quay, it follows that the walls of the sheds must be about 30 metres from the edge of the quay.

By siting the sheds in this manner, a 30 metres wide apron is obtained which may be suitably used as follows, reckoning from the edge of the quay.

Free space between the edge of the quay and crane leg	1.5 m
Crane leg	1.0 m
One railway track	5.2 m
One lane of vehicles or parking place for vehicles or freight	3.0 m
Crane leg or crane track	1.0 m
One lane of vehicles or parking place for vehicles-freight	3.0 m
Storage space for freight	15.3 m
Total	30.0 metres

The space for stacking freight in front of the sheds will thus be about 15 metres. If motor-powered trucks are used for shifting freight on this apron, this free space will be decreased to about 11 to 12 metres.

A free space in front of the sheds has proved to be particularly suitable for the storage of export freight which shall be put on board a vessel shortly, or immediately, after the vessel has been unloaded. It is of importance that the freight should be readily available as soon as the vessel can receive it, and it is difficult to marshal the railway wagons or vehicles which bring the freight down to the quay at the correct time. If this latter way can be arranged, it is the most satisfactory solution, as it allows direct loading of the vessel to be done. However, it is arranged, it is of the greatest importance that the vessel is not kept waiting. If direct loading can be carried out, and in this case, with only one railway track, it will primarily have to be done from vehicles, a generous provision of space is demanded for the circulation of traffic on the apron. The storage area mentioned above can be used for this.

The apron should be as even as possible to facilitate truck transport, and rails should be made flush with the deck. On quays for ocean-going vessels, the sheds should be about 60 metres deep. In ocean berths of 180 metres, the length of the sheds may be about 80 to 100 metres long, and about half the length of the berth. The floors of the sheds should be preferably horizontal. If ramps have to be provided, they should be given a slope of not more than 1 : 125 or 1 : 150. A truck with solid rubber tyres and with the brake off will not run away on a concrete floor with this gradient. Loading platforms 4 to 5 metres wide may be constructed along the rear of the sheds for transferring freight to vehicles and railway wagons and at the ends of the sheds for loading vehicles. There should be two to four railway tracks sunk flush with the roadway at the rear of the sheds. Beyond the railway tracks is a roadway to take 4 lanes of traffic with a footpath on the farther side.

A quay laid out in the above way will have a total width of:
30 + 60 + 5 + (9 to 18) + 18 = 122 metres to 131 metres (Fig. 1).

If the shed must be constructed of two floors, due to lack of sufficient space for a shed of only one floor, it should be arranged, if possible, so that vehicles can be driven up to the second floor. Balconies on the second floor should be made 4 metres wide, and should overhang the previously-mentioned freight storage area. This area is not thereby lessened but crane loads cannot now be placed nearer than 5 metres, instead of 2, to the front wall of the shed.

If the shed is to be constructed of more than two floors, which may be considered when the shed is to be used also as a warehouse as in the case in the free ports of Stockholm, Gothenburg and Malmo, the balconies on the upper floors should be at least 3 metres wide.

In those cases where the balconies are constructed by stepping back the building itself, the previously-mentioned storage area (15.3 metres) on the apron in front of the shed walls will be encroached upon. It should not be decreased to less than 7.5 metres width, to which may be added the 4 metres below the first floor balcony.

For storeys higher than the second, a total width of only 14.3—7.5—4.0=3.8 metres is commanded by a crane of the type chosen. This is not enough for more than one additional storey. By extending out the third floor balcony 1.5 metres over the second floor's 4 metres wide balcony and the fourth floor balcony 1 metre over the third floor's 3 metres wide one, and by giving the fifth floor short stretches of balcony (7 metres long for ex.) which completely overhang the fourth floor balcony, storage space can be increased by providing three further floors which can be reached by the crane. The shed can thus be built up to five storeys high. (Fig. 2). It is only in special cases, however, that it is advantageous to construct a combined warehouse and transit shed of more than four storeys.

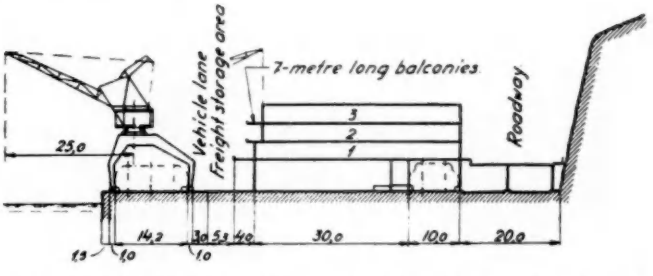


Fig. 4. Quay lay-out on two levels with a shed of three storeys above quay level. Alternative 1.

1 (b) **An apron with at least two railway tracks laid close to the edge of the quay and with a shed of one or more floors.** (Fig. 3).

To conform to the need of rendering direct loading and unloading possible, two or three railway tracks are usually extended along the edge of the quay. If there are three tracks, the inner one usually serves as a shunting line for the other two. When it is not being so used, it may be used for vehicle traffic or as a park.

For the same reason as in example 1a, the shed walls should not be sited nearer to the edge of the quay than 30 metres.

Quay Lay-out – continued

With the sheds sited in this way, the apron between the edge of the quay and the sheds can be laid out as follows:

Space between edge of quay and crane leg	1.5	m
Crane leg	1.0	m
1 railway track 2.6 + 2.25 m	4.85	m
1 railway track	4.50	m
1 railway track or lane of vehicles, parked or moving	4.85	m
Crane leg or crane track	1.0	m
1 vehicle lane or park for vehicles/freight	3.0	m
Freight storage area	9.3	m
Total	30.0	metres

From this table it can be seen that the distance between the rear crane rail or track and the shed walls is 12.30 metres. This space may be considered sufficient for trucks which need to manœuvre in front of the sheds, for the placing of freight to be taken into the shed, and for the temporary storage of any small quantities of freight which are awaiting transport from the docks or being loaded on to a vessel.

In a shed with two storeys, the second storey balcony must be built out over the area intended for the storage of freight. If this balcony is given a width of 4 metres, a space of 8.3 metres still remains between the rear crane rail and the edge of the balcony in which the crane can place freight on the apron. This may be considered sufficient.

If the shed is built of three storeys, the third floor can have a balcony 3 metres wide running the whole length of the shed, provided that the walls of the third floor lie 1.5 metres inside the ground floor walls, i.e., 31.5 metres from the edge of the quay. A crane of the type envisaged, with a reach of 31 metres from the edge of the quay with a 1.5 ton load, can then reach the centre line of the balcony on a 14 metres length opposite the crane's position.

The third storey balcony overhangs the second by 1.5 metres. This decreases the free space above the latter to 2.5 metres, but this is considered sufficient.

A further storey may have short balconies situated directly above the full length balcony on third floor. (Fig. 3).

The surface of the apron, its slope, and the railway tracks and roadway behind the shed, are arranged in the same way as in case 1a.

1 (c) **A quay lay-out on two levels with a shed of one or more storeys above the upper level.** (Figs. 4, 5 and 6).

A quay lay-out on two levels must be resorted to if the available area is so narrow that a sufficiently wide lay-out on one level cannot be used.

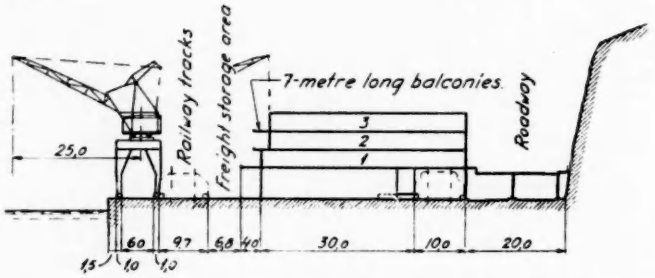


Fig. 5. Quay lay-out on two levels with shed of three storeys above upper quay level. Alternative 2.

One of the levels, preferably the lower one, should have railway facilities, and both should be directly connected to the harbour road system.

The lower level, then, will be mainly used for direct loading railway wagon—vessel, and for the storage and reloading on to vessels of (export) freight which has been brought in either by rail or road transport. The upper level will be mainly used for incoming freight discharged from vessels which cannot be directly reloaded on to railway wagons, but which must be stored or be taken away by road transport.

As doubling of the quay levels means higher installation costs, it should not be resorted to except in harbours handling substantial traffic demanding good rail communications.

The lower level should be provided with two or three railway tracks along the edge of the quay and, in addition, with a 7—8 metres wide space for vehicles and for the storage of freight to be loaded by crane to vessels. The upper level can then run 26 metres from the edge of the quay, and the sheds on this level can be built with their walls 30 metres from the edge of the quay. They may be built of one, two or three floors with 3 metres wide balconies so situated that they lie within the working area of the

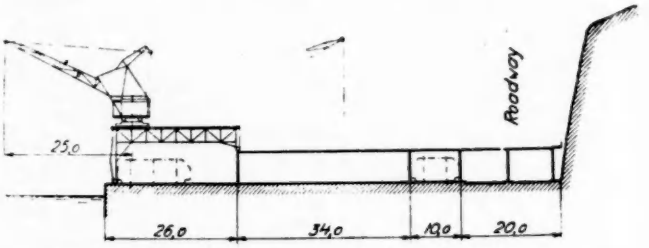


Fig. 6. Quay lay-out on two levels with bridge cranes.

type of crane envisaged. The second storey balcony (reckoned from the upper level) must overhang the upper quay level by 1.5 metres, and the third floor can only be given short lengths of balcony situated directly above the full-length balcony of the second storey.

Lay-out of the apron in front of the sheds can be made on the following plans:

Alternative 1. (Fig. 4) **Lower Level**		
Space between edge of quay and crane leg	1.5	m
Crane leg	1.0	m
1 railway track	4.85	m
1 railway track	4.50	m
1 railway track	4.85	m
Crane leg or crane track	1.0	m
1 lane for vehicles or freight storage	3.0	m
Storage space for freight in the open	5.3	m
Total distance from edge of quay to upper quay level	26.0	metres

Alternative 2. (Fig. 5). **Lower level**		
Space between edge of quay and crane leg ...	1.5	m
Crane leg	1.0	m
2 lanes of vehicles	6.0	m
Crane leg	1.0	m
2 railway tracks	9.7	m
Storage place for freight (poss. 1 railway track, 4.5 + 2.3 m for freight)	6.8	m
Total distance from edge of quay to upper quay level	26.0	metres
Upper Level.		
Distance from edge of key as above	26.0	m
Storage space for freight in the open	4.0	m
Total distance from edge of quay to walls of upper level sheds	30.0	metres

If the shed has two floors above the upper quay level, the balcony on the second storey must overhang by 1.5 metres the 4 metres wide space for storing freight on the upper level. The width of the balcony is taken as 3 metres. The crane can then place a 1.5 ton load on this balcony on a length of approx. 14 metres opposite the position of the crane. If the shed has a third floor, it can only be given short lengths of balcony (7 metres long, for example) situated directly above the full length second floor balcony.

With the type of crane chosen, a gantry crane with a 25 metres radius of reach, one cannot reach further than about 4 metres

Quay Lay-out—continued

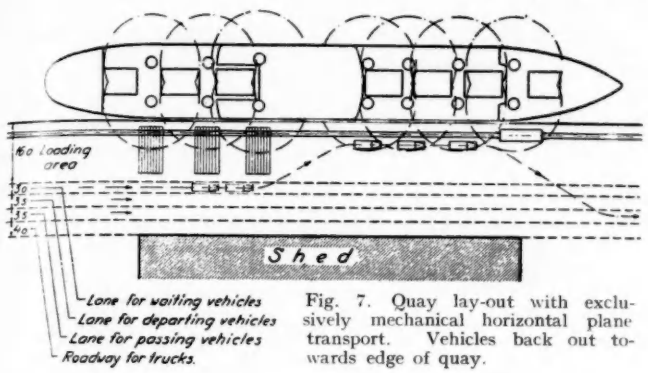


Fig. 7. Quay lay-out with exclusively mechanical horizontal plane transport. Vehicles back out towards edge of quay.

over the upper quay level. To get a really efficient result, a bridge crane must be resorted to with about 24.5 metres lateral travel. It is then possible to reach in a little more than 20 metres over the upper quay level with the crane (Fig. 6).

Provided that the shed buildings are situated at a distance of approx. 30 metres from the edge of the quay, it has been shown above that an apron can be arranged to provide ample space both for the direct loading of vessels, railway wagons and vehicles, and for placing loads on the apron using the type of crane previously mentioned, a rotating level luffing gantry crane with a radius of reach of 25 metres and mounted on a movable full or semi-gantry.

With multi-storey sheds, the open space in front of the sheds will be a little narrower. One storey sheds are thus the most advantageous, as plentiful space is thereby obtained for the placing and sorting of the freight in front of the sheds.

If the harbour has multi-storey combined transit sheds and warehouses as is the case in the Free Port of Stockholm, it is better to make use of level-luffing bridge cranes with lateral travel, as has been done in this harbour. These cranes reach so far over the quay deck that the free space in front of the sheds and the balconies may be given any width desired. In planning new general cargo harbours, however, one should think carefully before planning them so as to make bridge cranes necessary, as the delivery time and cost of such cranes are very great.

2 EXCLUSIVELY MECHANICAL MEANS OF HORIZONTAL PLANE TRANSPORT FOR SHIFTING FREIGHT ON THE APRON FROM THE SIDE OF THE VESSEL. (Fig. 7 and 8.)

Without the use of cranes, freight unloaded from, or being loaded into, a vessel must be placed on the apron within a " loading area " situated along the edge of the quay, and having a width which permits the winches and derricks of the ship to place or pick up freight of different sorts anywhere within their working area. The freight is either brought to the loading area or taken away from it by rail or road transport.

In deciding the maximum necessary width of the loading area, the first consideration is the reach of the vessel's derricks. This will probably not exceed 8 metres beyond the side of the vessel in the majority of cases. The extent of the loading area beyond this limit will depend on how bulky the freight in the slings is. Two metres beyond the reach of the derricks should normally be sufficient. One can, however, conceive cases where long bulky articles have to be set down with their length at right-angles to the edge of the quay. With derricks reaching 8 metres beyond the side of the vessel, it should be possible to set down freight 16 metres long, such as beams, piping, etc., in this way. Such freight would require a loading area of this width (16 metres). Normally, a higher rate is charged for freight exceeding 12 metres in length, so that this figure might be arbitrarily fixed as a normal maximum length for freight. The loading area required would then be $8 + \frac{12}{2} = 14$ metres wide. Of this area, a strip of approx. 2 metres wide. Of this area, a strip of approx. 2 metres wide at the edge of the quay should be kept clear to provide access to the vessel and to the mooring ropes.

In order to make the best use of the overhang of the derricks and the space on the apron, it is probably best to extend the loading area out to 16 metres from the edge of the quay.

A railway track with its centre-line 3.2 metres from the edge of the quay can be laid through the loading area. With wagons on the track, this leaves a free space of 1.5 metres between the wagons and the edge of the quay, which may be considered satisfactory. Freight can be picked up or set down on a 2 metres wide strip of the apron 6 to 8 metres from the edge of the quay on the shore side of the wagons. The railway track should be flush with the surface of the apron to enable freight to be stacked and vehicles to use the area when no railway wagons are parked there.

The vessel's derricks should be able to place freight within the loading area along two-thirds of the vessels length, and each derrick should be able to command a length of 10 to 12 metres of the quay side at a distance of 6 metres from the edge.

All freight must be set down or brought into this loading area, whether it shall arrive or be taken away by rail or road transport, or by truck to or from storage places further back on the apron.

To be able to make use of the loading area efficiently, vehicles driven into the area for direct loading should be parked with their length either at right-angles or parallel to the edge of the quay. That is to say, either backed out towards the edge of the quay and at right angles to it, or driven in a line along the edge of the quay. To decide the space necessary for vehicles and trucks between the loading area and the sheds, the following two cases must then be considered:

2 (a) **Vehicles backed out towards the edge of the quay. Necessary width of the apron in front of the sheds. (Fig. 7.)**

Free space between edge of quay and freight, vehicles or wagons ...	1.5 m	
Space for freight and railway track ...	8.5 m	
Loading area		10.0 m
Turning area for backing, and space for departing lines of vehicles ...		12.5 m
Lane for passing vehicles		3.5 m
Roadway for trucks		4.0 m
	Total	30.0 metres

2 (b) **Vehicles passing along the loading area in file. Necessary width on the apron in front of the sheds.** (Fig. 8).

Free space between the edge of the quay and freight, vehicles or wagons ...	1.5 m	
Space for freight stacked with its length at right-angles to the edge of the quay and railway track	14.5 m	
		16.0 m
Lane for waiting vehicles		3.0 m
Lane for departing vehicles		3.5 m
Lane for passing vehicles		3.5 m
Roadway for trucks		4.0 m
	Total	30.0 metres

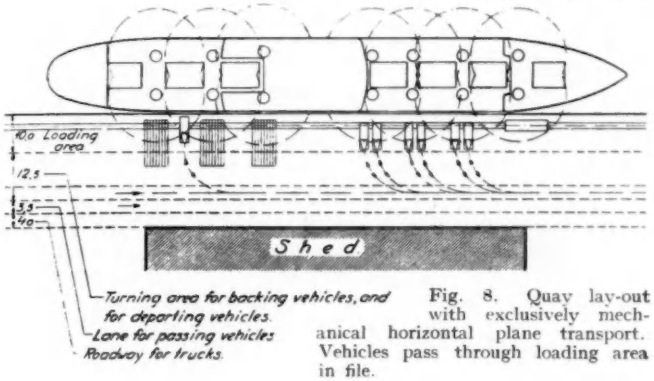


Fig. 8. Quay lay-out with exclusively mechanical horizontal plane transport. Vehicles pass through loading area in file.

Quay Lay-out—continued

As these tables show, there should be space behind the loading area for a lane of departing vehicles and of passing vehicles, both one-way traffic, and a roadway for trucks with two-way traffic.

When the vehicles are backed into position (case a.) the loading area need not be reckoned as being more than 10 metres wide, as vehicles can then back in between those places where loading or unloading of long, bulky freight is going on.

When vehicles approach the loading area in file, on the other hand (case b.), regard should be paid to long and bulky freight, and the loading area taken as being 16 metres wide.

When trucks are used, the space should be sufficiently large to enable them to fetch or deliver their loads either at right-angles or parallel to the edge of the quay. Should truck trailer trains be used, either each trailer can be uncoupled and loaded or unloaded separately, or the complete train can be driven into the working area of the derricks, as these trains have usually a relatively small turning circle.

As can be seen, even in this case the sheds should not be sited nearer to the edge of the quay than 30 metres.

As previously mentioned, sheds of one storey serving ocean traffic should be given a width of about 60 metres and a length of between 80 and 100 metres. Behind the sheds are three to four railway tracks, and along the rear of the sheds, loading platforms for railway wagons and vehicles with platforms for vehicles at the ends of the sheds.

Where goods shall be stored, the slope of the apron should not exceed a gradient of 1 : 125 or 1 : 150.

If multi-storey sheds are required, each storey should have a ramped drive-in for vehicles and trucks or truck trailer trains to enable the transport of freight between the loading area and the sheds to be carried out as speedily as possible.

For transport of freight between different storeys of the shed itself, and when reloading from the shed to railway wagons or vehicles, lifts, freight elevators and chutes can be made use of as there is not then the same degree of urgency as when handling large cargoes from vessels.

The above exposition shows that the siting of sheds on an apron should be done in approximately the same way, whether quay cranes, or ships derricks and horizontal plane transport are the means used for loading and unloading vessels.

To be able to decide whether trucks and truck trailer trains can replace expensive cranes, it may be necessary to carry out exhaustive practical, comparative experiments in one harbour using both methods of operation. It should be possible to carry out such tests in any harbour where the distance between the sheds and the edge of the quay is about 30 metres without any danger of the trucks being obstructed by the fact that the harbour was not originally designed for such transport.

The problem of how best to lay out the apron in a general cargo harbour is of great importance in rationalising harbour routine and constructing new harbours. It is desirable, therefore, that this problem should be more generally discussed among harbour staffs. The views given here are intended to act only as suggestions, to be brought up at any discussion.

Shipboard Cargo Gear

Need for Improved Efficiency

At the annual banquet of the Society of Naval Architects and Marine Engineers (New York), which was held recently in New York, an interesting speech was delivered by Mr. Frazer A. Bailey, the President of the National Federation of American Shipping. Many shipping topics were covered in his address, but the one of greatest interest to readers of this Journal was his suggestion that naval architects and engineers could perform a very important service to the maritime industry by improving the methods of cargo working on shipboard.

Mr. Bailey pointed out that there was nothing in the history of loading and discharging ships which justified any complacency, and said that " about 75 years ago, a man named Burton hung a pole on the mast of a sailing ship, and with a wood-burning donkey engine and a single fall, began to lift bales of cotton or hogsheads of tobacco through small hatchways into and out of the holds of sailing vessels. Unfortunately, we are doing substantially the same thing to-day. While there have been some improvements, it is hard to believe that great economies in cargo handling cannot be accomplished by further and important advancement in ship design and cargo handling."

Time Lost in Cargo Handling

Stressing the need for a reduction of cargo handling costs, Mr. Bailey suggested that the first objective was the creation of physical conditions permitting the landing and removal of sling loads in the ship's hold to and from stowed position. When he was in the active ship-operating business they made some careful studies of lost motion in stevedoring. They found that 25 per cent. or more of the total man-hours were expended in breaking down sling loads and moving cargo from the square of the hatch to the wings, or to the forward or after bulkheads in the hold.

If, under the stimulus of war, ships could be designed which ran upon beaches, opened their hinged bows, dropped ramps and permitted vehicles and cargo to land on the shore, he for one was not prepared to admit that they could not greatly improve their ship gear and terminal designs for cargo handling. Very recently an ingenious plan was devised for rolling 'tween deck sections under the hatch areas, there to be loaded and rolled back to the wings, thus avoiding the necessity of the re-handling just mentioned. It was a step in the right direction. He believed, however, that, somehow and in some way, American naval architects would design a vessel into the holds of which sling loads of cargo might be landed, there to remain until lifted bodily out of the vessel at the time of discharging, without disturbing the sling loads and man-handling cargo to individual stowage locations.

Need to Eliminate Rehandling

It might be possible to augment this improvement in certain instances by the use of containers or palletizing, and these methods should be thoroughly explored, but the major operation was to overcome rehandling, and to reduce the time required in rigging gear, and covering and uncovering hatches.

Along with that, the speaker continued, was needed modernisation and redesigning of terminals. A system should be developed under which delivery and receiving trucks did not pass, or take up a position, between the ship's side and the point of rest of the cargo on the deck. When that occurred the stevedoring operation, be it loading or discharging, was brought to a virtual standstill. Any efficiencies effected elsewhere were nullified. The quay-type terminal where trucks might take cargo from the opposite length-wise side of the dock without interfering with the stevedoring operations justified exploration. If they could thus reduce the cost, they would automatically reduce the loading or discharging time, and the overall port time and turn-round schedule of the vessel.

Container Traffic at Port of Belfast.

At a recent meeting of the Belfast Harbour Board application was made for a berth at Belfast equipped with rail connections, shed accommodation, a ramp for bow discharge and cranage facilities, and an adjacent parking area, for use with the ex-tank landing craft *Mowbray Road*. It was stated in a letter read at the meeting that traffic conveyed by railway-owned containers is increasing to such an extent that to cater for it, and supplement existing services, the Railways Executive (London Midland Region), are contemplating, under a long-term policy, the construction of ships of special design similar to the *Princess Margaret*, plying between Larne and Stranraer, which will load and discharge wheeled vehicles, and trailers carrying containers, through an aperture in the stern, together with general cargo stowed in the hold by means of cranes of at least 10 tons capacity.

The International Association of Navigation Congresses

Review of Papers Presented at the Lisbon Congress, 1949

(Continued from page 248)

Last month we published the General Report by Mr. H. Schreck upon the papers dealing with Question 1 of Section 2—Ocean Navigation, i.e., Improvement of Estuaries.

In the pages of this issue, the Review of papers submitted to the Congress is continued with an abridged version of Mr. Alves' General Report upon Question 2—Oil Handling at Ports, which was to have been published in the December number of this Journal, but, owing to lack of space, had to be postponed.

The subject is naturally a very wide one, embracing not only navigation and conservancy problems affecting ports, but also inland communications, loading and unloading, storage facilities, fire risks, and segregation questions.

Mr. Alves, in order that his report should be of reasonable length, was unable to refer specifically to each paper presented, much as this was to be desired, in view of their importance and thoroughness. He was therefore compelled, with apologies to the writers, to deal merely with the fundamental ideas extracted from each of the papers, as he duly stresses in the conclusions at the end of his report.

Owing to space restrictions, it is only Mr. Alves' introductory remarks and conclusions upon the subject that we have reproduced below.

SECTION II.—OCEAN NAVIGATION.

Second Question.

Facilities of port depots for loading, unloading and storage of fuel oils (including mechanical equipment).

Segregation of such depots (and refineries) from other parts of ports; other special measures for reducing risks from fire or other causes.

Best location for oil-storage and for oil refineries within port boundaries.

Facilities for movement of fuel oils inland from the port.

Experience resulting from the war.

GENERAL REPORT BY M. JOAO CARLOS ALVES M. C.

Ing. Civil et Industriel, Ancien Directeur du Port de Lisbonne, Membre du Conseil de l'Administration Générale du Port de Lisbonne, Chef de Travaux à l'Institut Supérieur Technique de Lisbonne, Capitaine du Génie.

Papers from seven nations have been presented to this Congress on the subject of the Second Question of Section II. The countries and the authors are:

DENMARK: M. Rode	(1 paper)
FRANCE: MM. Callet, Conteaud & Deschênes ...	(1 paper)
GREAT BRITAIN: Messrs. Owles and Hall ...	(2 papers)
ITALY: MM. Alfred Camanzi and Lino Fermi ...	(1 paper)
NETHERLANDS: MM. Tuyn and de Roo de la Faille	(1 paper)
SWEDEN: MM. Jansson and Westrell	(2 papers)
U.S.A.: Messrs. Besson and Smith ...	(2 papers)

Introductory Remarks

Before approaching the subject matter of this report, it should be pointed out that it has never been so widely dealt with as at this congress.

Only one part of it formed the subject of a communication at the XIV Congress (Cairo 1926) under the heading: Reception and storage of liquid fuel (metal and reinforced concrete reservoirs).—Precautions against Fire.—Distribution of liquid fuel in ports.

The problem of storage facilities and safety was discussed, as can be seen from the conclusions of this report*.

It is astonishing that this question was not dealt with later, not even at the Brussels Congress in 1935, a year in which the transport by land and water of petroleum, as concerned trade ports, was already fairly large and the consumption of these products very widespread, although at the congress of Cairo the necessity was recognised of framing general conditions for the plant of petroleum ports (importing and exporting), as well as safety measures to be adopted and the results obtained.

As problems of this kind were not discussed at recent Congresses (Venice and Brussels) the question, which has this time received worthy notice (2nd Question), is somewhat novel to a large number of the members of the present congress. Possibly it is on account of this circumstance that the theses put forward do not refer to basic problems, but are restricted to almost generalities and to a description of plants existing in countries which the authors represent.

The French paper (Messrs. Callet, Couteaud and Deschènes) deserves, however, to be excepted from this general concept; it is presented as a minor review of the four first points of the 2nd Question; the same applies to the paper by Mr. Hall (Great Britain) which, by its clarity and spirit of synthesis, forms an excellent aide mémoire for those who are not sufficiently acquainted with the subjects which form the heading of this 2nd Question, worthily included in Section II (Maritime Navigation) of the XVII Congress.

Worldwide consumption of petroleum and its derivates is increasing rapidly (nearly 400 million tons in 1947, in 1948 it will reach or even exceed twice what was used in 1938). The causes of this economic phenomenon are widely known: transport by land, sea and air, industries of all sorts and other varied activities all employ petroleum products as fuel or mere raw material.

It has been justly stated that petroleum was the nerve-centre of the last World War which, contrary to World War I, was a war of continual movement in which transport played a very important and decisive part in the Allies' victory.

But it is not wars that revealed the extraordinary role which petroleum was to play in world economy. Since the beginning of this century the use of internal combustion engines in motor vehicles soon gave a foretaste of the great development which transport would bring to the petroleum industry and the multiplicity of its uses as sources of thermic energy, passing thus from a simple combustible liquid for lighting purposes to an industrial fuel! In fifty years a veritable revolution has taken place in industries, similar to that which coal brought about at the beginning of the XIX century.

As is the case with coal, the supplies of petroleum are unequally distributed on the surface of the world and unfortunately less profusely than coal, of which the the apportionment however is less concentrated, but without amounting to the great regional reserves which characterise oil fields (America, Caucasus, Persia, Arabia and the Balkans).

Owing to this fact most countries are situated far away from the producing centres, which forces them to import large quantities which only maritime traffic on a big scale can supply. In conjunction with maritime and fluvial transport, there are of course adequate harbour installations and those for reception and storage.

As the transport distances from the oilfields to the large consumer centres are mostly very great, and freights consequently high, tankers are constantly increasing their carrying capacity; one might even say these vessels are passing through a growth-crisis; tankers of 45,000 tons, with a draught of about 36-ft., are already planned! Concomitantly, efforts are made in all directions to shorten the turn-round in ports, by speeding up discharging and loading, to increase the number of annual voyages per vessel, especially for large tankers. On another hand, and with the same aid, the speed of these vessels is increasing: 12 knots is frequent and the tendency is to do even more (15 knots); it is foreseen that even 18 knots will be reached.

To reduce the cost price, so as to be able to compete with the international markets, it is necessary for an importing country to build refineries whose output is at least 1,000,000 tons, which is equal to the consumption of 2,000,000 inhabitants, reckoning an annual allowance of 500 litres in much industrialised countries.

The capacity of installations ashore served by shipping (ports) depends on the volume of tanker traffic, according to the kind of

*See end of this report: Conclusions on the 2nd Communication of Section II (Maritime Navigation), Cairo 1926.

International Association of Navigation Congresses—continued

products imported and their respective distribution inland. As to capacity of reservoirs storing the products received by tankers, a similar growing-crisis is noticed to that of the vessels because, to a certain extent, their capacity ought to be, as far as possible, equal to or more than that of the largest vessels plying to the port. The capacity of the standard reservoirs was formerly about 10,000 tons, but nowadays one reckons on some 36,000 tons, although oil tanks of 15,000 and 20,000 tons are currently constructed.

If an increased volume of such reservoirs has the advantage of requiring less space, it has the drawback of less safety and seriously increased risk.

As far as maritime works are concerned, the reception of petroleum products in countries of old civilisation, such as the European countries, is done in large ports already in existence by using the outer works already built (shelters, entrances, etc.) and the same conditions as for commercial vessels arriving there, and other facilities which are common to both (entrances to docks, repairs, maritime services in port, etc.).

Petroleum plants should, whenever possible, be far away from commercial zones of harbours and consequently possess their own plant for reception, handling and re-forwarding of oil and fuel.

Sundry Notes

To conclude, we ought to stress the interest attached to a study of the theme of this 2nd Question, especially as regards the harbour installations themselves and also the most favourable site for warehouses and the refinery. One must not forget safety measures in petroleum installations, including the refineries, viz., isolating them from other harbour installations.

The papers are almost unanimous, when dealing with these matters, in recognising the advisability of constructing separate docks or harbours for handling these products and that they should be isolated from all commercial or inhabited zones, as well as strict observance of applying all possible means of reducing the risk of fire both ashore and afloat.

In view of the great importance of this matter in the construction of harbours, it would be helpful to place the question on the agenda of future congresses, as there will be few ports with heavy traffic, especially terminal ports, that do not possess installations of this kind or will not eventually have such.

The following conclusions will not contribute anything of great novelty to the knowledge of experts on the 2nd Question who are attending this Congress (and even less to the illustrious authors of the papers presented), as they deal with generalities studied and discussed for a long time past. We merely wished to condense them as postulates that may serve as practical rules to those initiated in the construction of petroleum harbours, or in the adaptation of harbour works already in existence, to this technical branch for civil engineers who devote themselves to maritime and fluvial works, even if in close co-operation with engineers specialised in the handling of petroleum matters.

Conclusions

1st Conclusion:

The scope of the first part of Question 2 is difficult to condense because the point it raises depend on various factors concerned with economics, trade, technique and the physico-topographical conditions which one has to co-ordinate to create a good installation—a materially difficult thing to achieve.

Such an installation would be one comprising elements harmonising with each other and such as would fully achieve all the aims desired.

As such a desideratum sometimes approaches the ideal, let us imagine, in the present state of petroleum handling, a plant that might be termed "optima":

(a) **Petroleum Harbour:** This should be exclusively given up to handling petroleum or, at any rate, be situated alongside a port already in existence, in its own docks or basins, isolated, and if possible away from other commercial zones.

As a separate port or basin, it should possess all requisite means of shelter and mooring; sufficient depth of water to accommodate tankers; safety measures and its own plant for maritime and fluvial operations and the handling of products imported or to be exported; means for bunkering vessels using (or which might use) the petroleum harbour, so that all traffic and handling can be done rapidly and safely.

As a petroleum harbour increases constantly in function of its capacity, all the port installation should be in perfect keeping with its traffic, the mooring places or quays in particular, as their extension should be compatible with the number and length of vessels to be handled. Thus, it will be necessary to provide for tankers of 180 to 200 m. length and a draught of 33 to 36-ft. It should be possible to close the docks or basins, to prevent fire spreading, especially when they communicate with a roadstead or basin in the commercial harbour.

It would be an advantage to construct a small safety-inlet in case of fire aboard, to shelter vessels in danger and to meet abnormal cases (war, serious accidents, etc.).

(b) **Piping:** Each mooring place or quay should have at least five sets of piping for the various kinds of oil imported (crude petroleum, heavy oils, gas oil, petroleum and petrol (gasolene)). If several petroleum companies exploit the port, there should be a joint piping ending in a central pumping station (when pumping is not done aboard) and distribution-building, from which would branch off piping belonging to each individual company.

(c) **Reservoirs:** In order to economise their construction, they are usually built above ground level of steel sheeting. Their capacity tends to increase mainly when space is scarce.

As a safety measure, they should be separated or isolated in two groups according to the degree of inflammability of the products to be stored in them, surrounded by retaining-walls forming individual basins having a capacity equal to that of the reservoir itself.

In certain cases one might recommend the use of plain or reinforced concrete (duly protected inside against corrosion), embedded or half embedded, with the shape most suited to the geological nature of the ground.

The warehousing zone should not be too far away from the mooring places of the tankers—only what is indispensable to avoid the spreading of any fires that break out on board or ashore.

(d) **Refineries:** For safety reasons, these factories should not be built inside petroleum harbours but preferably as far as possible in flat areas, but not too distant from the shore of the port and from the reservoirs which receive the products from vessels or which are intended for distribution. As a rule, the term "refinery" includes the whole harbour complex: reservoirs and factory properly speaking, and in a more restricted sense the factory and reservoirs for finished products.

In that case, one must consider its situation as regards large consumption-centres, not forgetting existing dwellings that might be on the geographical or topographical site to be selected for its erection, not only on account of the risks they might run but also for considerations of a hygienic nature.

(e) **Machinery:** The whole installation must be provided with the mechanical equipment necessary for handling peroleum traffic, such as: pumping stations, heating of the piping, a supply of water under pressure, compressed air, means for attacking fires, fixed or mobile, maritime or on land, a bunkering-network, all in separate places without being distant, to avoid excessive concentration of them.

(f) **Edifices, houses for staff, social work:** Whenever possible, edifices should be situated outside the additional protection-zones, except those directly connected with the technical operation of the factory (laboratories, small offices, etc.). Dwelling places for the workers and recreation rooms for crews (sleeping quarters, mess-decks) should be erected outside the outer protective perimeter, not only for safety reasons but also for pyschological reasons, in order that the staff and workers should not live permanently in the same surroundings as that of their work, as well as from other motives of a hygienic nature, especially in the neighbourhood of refineries which emit gases which, although not toxic, may in spite of everything be prejudical to the health of employees and workers.

International Association of Navigation Congresses—continued

2nd Conclusion:

Isolation measures and protective means against all risks, especially fires endangering petroleum installations, maritime and on shore, are numerous and distinct.

They can be enumerated, with the requisite extension and efficacy, as follows:

(a) Screens for separating basins or docks reserved for handling petroleum, anchorage and mooring places for commercial and other vessels, especially for loading ships with low flash point products.

(b) Floating isolation-closures which supplement the closure of a petroleum dock or harbour, especially when there are fluvial or tidal currents outside.

(c) Cleansing water-areas polluted by seepage during discharging of vessels or for other reasons.
This cleansing-service avoids the risk of fire and pollution of water in the harbour and waterside structures, as well as enabling the recuperation, although expensive, of appreciable quantities of oil.

(d) Special precautions against fire, seeking to keep shore installations away from the quays. If the reservoirs are of a large capacity (over 20,000 m^3), there should be a distance of some 100 m., to minimise the danger of heat spreading and flying sparks carried by the wind and wind convexion movement. The harbour must be protected against seepage of large volumes of oil on fire (permeable soil in the protective zone and a slight or no declivity towards the water in the harbour, circular ditches, etc.).

(e) Strict observation of anti-fire regulations as regards: light and power electric installations, naked flames, easy access to all the plant to combat fires; enclosure of all danger-zones and additional protection-zones; cleansing of all premises of matter that is easily inflammable (paper, litter, dry grass, etc.), as well as the loading and discharging plant.

(f) Instil into the minds of the personnel (who are almost always the involuntary cause of fires) the notion of risks and dangers to the plant and personnel themselves by negligence or lack of care.

(g) To possess all the means, fixed, mobile and floating, for fire-fighting, among which are a plentiful water supply under pressure, and extinction-appliances (compressed inert gas, carbonic snow, carbonic foam powders and solutions, etc.) removable to all the harbour equipment.

(h) Protection against explosions. This danger is, generally speaking, rare because it is difficult to reach the requisite degree of concentration of inflammable gas and atmospheric air likely to cause an explosion, in contact with or under the influence of an abnormal temperature or source of heat. This danger, which may reach terrible proportions, can only be overcome by distance. For that reason, it is advisable to have distances of 750 to 1,500 m. between the harbour installations and commercial zones, edifices or large factories, residential areas, monuments, etc.
The most frequent danger of explosions lies in empty and non-degassed spaces (reservoirs, tanks of ships after partial or total discharge). Vessels must be de-gassed away from the discharging-plant, whilst reservoirs should have appliances which reduce cases of explosion to a minimum (hydraulic counterbalancing, floating caps, high pressure reservoirs — spheroids — or medium pressure, buffer-gasometers fitted to all roofs of rigid reservoirs, etc.).
These precautions lessen the risk of explosions and have in addition the commercial advantage of reducing loss by evaporation.

As there are no international regulations prescribing the precautions to be taken in petroleum harbours, recourse is had to very varied measures which change from country to country and port to port, and it is suggested that the most universal safety measures should be duly codified by an International Bureau, with the participation of the Permanent International Association of Navigation Congresses.

3rd Conclusion:

The most favourable site for erecting reservoirs and refineries, in the widest sense, is a question which exceeds the general heading of this 2nd Question as set for the Congress, as the factors are multiple which condition the best position for such installations, either near petroleum harbours or inland. Consequently, only the former will be the subject of this conclusion:

(1) **Storage Installations.**

(a) The topographical conditions and the nature of the foundation-soil may decide the best site. Rocky soil such as gives good foundations makes the construction of embedded reservoirs almost impossible, in addition to the fact that it cannot supply adequate cheap material, earth or sand, for the construction of enclosure-walls round reservoirs.

(b) The most usual consideration is that reservoirs should not be far away from the maritime installations, while at the same time complying with the distances ordained by the regulations or by experience, and whilst taking all safety measures against seepage and the risk of fire, principally by preventing leakage reaching the water-area of anchorages or mooring-places of ships (petroleum and commercial).

(c) Account must be taken of future size and multiplication of reservoirs, keeping in mind the diversity of products to be consumed, as well as ease of access to transport means for carrying these products inland.

(d) It is most certainly advisable to separate reservoirs containing the most inflammable products from those holding less inflammable oils, as the precautions differ: they are much less stringent for the latter.

(2) **Refineries.**

(a) The erection of refineries may be assimilated to that of reservoirs in harbour zones: naturally level or suitably prepared ground, not too far distant from the maritime installations; open spaces for their future enlargement, including all the works necessary for their functioning and for the accommodation of personnel.

(b) To possess a private network of railways and roads connected to all the other harbour installations and, via these, to the country's main systems, with a view to facilitating transport of refined products, either by water or by land.

4th Conclusion:

The installations for the transport of petroleum products inland must not be rigid, nor solely of one kind, seeing that the cost of the various means of transport varies from time to time; consequently:

(a) It will be necessary to provide installations which have access to current means of transport (on land, fluvial and maritime) which will be used either on account of their nature or on account of the expenses per unit (ton) of products to be carried (pipe-lines, tank-barges, tank-wagons and tank-trucks).

(b) Pipe-lines are only advisable for the transport of large liquid masses, of slight viscosity at the ordinary temperature. Losses are extremely small, as compared to other means of transport. This system has, however, various difficulties as regards its operation, especially as regards contamination of products by others of a different kind.

(c) Fluvial transport is recommended when it is done by barges of large capacity and at the highest possible commercial speed, to lessen the time taken for each voyage.

(d) Railway transport is the most suitable means of transport for supplying large and medium sized consumer-centres, up to distances of not more than 200 kilometres, especially when the transport is done by complete train loads.
It is, moreover, of great flexibility for fractioned transport of products, even to great distances.

International Association of Navigation Congresses—continued

(e) Road haulage is perfectly adapted to retail distribution for short or medium distances, enabling direct distribution to be done from a petroleum harbour or large centres to the premises of a client.

5th Conclusion:

The fate of wars depends largely on fuel supply, whilst oil plants are always a target.

All defence measures during World War II proved inefficient to protect them from attack, especially aerial.

(a) The sole safety measure, as regards storage, is to build earthed reservoirs (or semi embedded and duly camouflaged) away from harbour zones or densely populated centres.

(b) As to the harbours, they should be built away from the influence of fluvial or tidal flows liable to sweep along leakages towards other harbour zones.

(c) Recourse to submarine pipe-lines in time of war is advisable on account of the great liberty they give to other vessels in case of attack.

(d) A measure common to all petroleum plants is to ensure their dispersal and their multiplication (in distance and quantity—harbours—storage—refineries, etc.) and, combined with this measure:

(e) Intensification of the manufacture of synthetic petrol (gasolene) in various parts of one and the same country, which avoids large imports of crude petroleum or commercial petroleum and also facilitates distribution inland, both in peacetime and wartime.

Conclusions on the 2nd Communication of Section II (Maritime Navigation), Cairo 1926.

1.—Both from the standpoint of commercial operation and that of protection in wartime, it is desirable, if possible, not to place reservoirs in the open but to have subterranean reservoirs, as this type also helps preservation of fuels.

The cost of building subterranean reservoirs may amount to three times that of building open-air reservoirs.

For liquid fuel the most economic types of reservoirs are those holding 10,000 to 12,000 tons.

2.—For open air depots, in the present state of technique preference should be given to metal tanks of all dimensions.

Reinforced concrete tanks have not hitherto given satisfactory results as regards impermeability. It is to be hoped that experimental research on these lines will be continued.

3.—With the aim of providing a maximum of facility and safety to general traffic, reception places and storage depots should be built on sites as far away as possible from other commercial installations. The use of isolated basins, closed by suitable barrages, is to be recommended; isolation-barrages for the protection of individual ships are difficult to construct and do not give sufficient guarantee.

4.—Evacuation of water loaded with hydrocarbons should be done outside harbours. It may be of interest to have in each port special barges to recover polluted water and then separate the hydrocarbons.

5.—In cases where there is a special basin for receiving hydrocarbons, it is desirable that the places (or stations) should be so organised as to enable any individual post to serve all the depots. This system gives a maximum output of the posts and may be of great help in case of fire.

Book Reviews

Dredging of Harbours and Rivers. Captain E. C. Shankland. Large 8vo. 266 pp. Published by Brown, Son & Ferguson, Glasgow. 42s. net.

This is a new edition of a very well known work, which has been used extensively by many harbour engineers, dredger masters and other persons concerned with dredging and retains its general value unimpaired. The Author has introduced a note to Chapter V (" Performance and Economics of Dredging ") to cover changes since 1928, and a new Chapter VI (" Modern Dredging ") aims to bring the reader up to date. Some of the illustrations are new.

Unfortunately, the Author has still not incorporated any matter concerning the sea-going trailing types of suction dredger. These are scarcely used in British home practice but have played such an important part in foreign sea approaches to harbours (Buenos Aires, Gironde, Wilhelmshaven, Shanghai, etc.) that their omission is not justified. He mentions some of these vessels by name but there is nothing to show that they do not work at moorings.

Radio telephony, welding and the use of diesel electric plant are touched upon.

This book is what is usually termed of a " strictly practical nature " and in so far it is quite good, but there is room for a much wider study of dredging problems. As yet no such work has appeared.

The Design, Construction and Maintenance of Docks, Wharves and Piers, by F. M. Du-Plat-Taylor, M.I.C.E., M.I.Mech.E., etc., published by Eyre & Spottiswood, 1949. Third Edition, price £5 5s. 0d.

The new edition of this book is the third; it has been revised and brought up-to-date and now contains data and facts which are the result of experience gained during some fifteen years.

Since the last issue was published considerable advancement has been made in scientific research and the war provided an additional impulse. The war years have also been responsible for some remarkable civil and mechanical engineering achievements, the details of which, owing to the secrecy necessarily involved at the time, are only now becoming known.

Several of the war-time temporary dock and harbour structures are mentioned, i.e., the harbour at Arromanches with its caisson breakwaters and floating pierheads, and the composite jetty of cast iron screw cylinders and reinforced concrete deck constructed at Cairnryan, not at Gareloch as stated in the text. While as to permanent structures a little difficulty was experienced in finding details of the notable dry docks at Capetown and Sydney. On the other hand the design of dry docks generally is admirably treated.

Among the chapters which have been greatly revised and enlarged is that dealing with Calculations for Dock Walls, in which are described, in considerable detail, modern methods of design based upon the most recent research work in Sail Mechanics.

The chapter devoted to Forms of Dock Accommodation is retained and in addition, the incidence of air transport services and the construction of aerodromes and sea plane bases as a possible part of future dock facilities is discussed.

Dock and Wharf Machinery has been considerably revised and amplified by the addition of data respecting recent types of machinery of many kinds, hydraulic power, impounding and dry dock pumping plant being specially treated.

Materials and construction of works is revised in the light of recent great improvements in the technique of concrete mixing, vibrated and colloidal concrete, cement gun work and many new types of constructional and excavating plant and cofferdam practice.

The work concludes with a chapter on the subject of Maintenance, which represents in all dock undertakings an annual charge of increasingly large proportions and is thus of great importance.

Dock engineering is a subject which embraces probably more branches of engineering than any other, and the author, confronted with a difficult task in both writing and revising a work on this subject has succeeded very effectively. Any omissions to fully deal with, for example, layout of quays, sheds, railways and roads together with modern cargo handling appliances is due, no doubt, to his efforts to keep the volume within reasonable limits.

Engineers must keep up-to-date their knowledge of the developments that are taking place in various parts of the world, of which there is published from time to time a wealth of information through the medium of technical institutions and journals, but there are few engineers who have the time to study in original all the literature. There is thus a great demand for condensed information, and a volume such as the one under review therefore contributes a most useful service in that it seeks to present, from many sources, the latest information in dock engineering practice.

The present edition is a work of much interest and will appeal to all those engaged in engineering work connected with docks.

Annual Reports of London, Liverpool and Newcastle

The annual reports of three of the largest ports in the United Kingdom were issued towards the end of November last, and the details were received too late for inclusion in our December number. As the particulars are likely to be of interest to readers of this Journal, we are printing the following abridged versions of the reports in question, in the order in which they appeared.

Port of Newcastle-upon-Tyne

At the annual meeting of the Tyne Improvement Commission held at Newcastle, Mr. W. A. Souter, who was re-elected Chairman, said the trade of the river continued to improve. Imports and exports of general merchandise for the first three-quarters of 1949 were 217,000 tons above the corresponding period of 1948 and were 113,000 tons more than in the same period in 1938. Coal shipments for the first 10 months of 1949 showed an increase over the previous year's figure of 564,000 tons.

At the present time there was still a good market abroad for their coal, and its sale, in spite of its high price, had been increased owing to the 40 per cent. advance in the price of oil fuel due to devaluation. It now appeared probable that the total trade in 1949 would be approaching one million tons more than in 1948.

Mr. Souter pointed out that there probably would be an increase in grain imports in 1950 and said that when a flour mill at Gateshead was completed in December, it would, with two existing mills, make the Tyne the largest milling centre on the East Coast. The increase in imports and exports had had a beneficial effect on the Commission's revenue and had enabled them to overtake some of the leeway in the redemption of debt which was lost during the war. Their debt was now £2,750,000 compared with £3½ million at the end of 1939. This was the lowest figure it had reached since 1875.

In conclusion, Mr. Souter said it was very desirable that if possible some reduction should be made in dues, the latter still stood at 100 per cent. more than pre-war and it would be a matter of consideration whether it would not be possible to make some reduction in 1951.

Port of Liverpool

Presenting the accounts for the year ended July 1, 1949, at a meeting of the Mersey Docks and Harbour Board. Mr. Edmund Gardner, the Chairman, said that an important factor of the finances was the receipt of about £6,600,000 as the final payment in respect of war damage. The total claim, as agreed, was approximately £10,800,000, but the Board had already received payments on account totalling about £3,300,000, and their own contribution was over £800,000.

The financial working of the year ended July 1 last was somewhat disappointing, as, in spite of an increase in revenue of over £250,000 they had only succeeded in balancing their general revenue account for the year.. The reason for this relatively poor result was that they had found it necessary to incur a greater expenditure on dredging than ever before.

The incidence of their trade had some interesting points of variation with the previous year, notably that the revenue from ships had increased by some £160,000. The revenue from goods imported foreign had fallen by over £100,000, while the revenue from goods exported foreign had increased by over £90,000. The reduction in inward traffic was in the imports from the dollar countries, offset in part by increases in the traffic from the sterling countries. By far the greatest part of the increase in exports was to countries of the British Commonwealth and Empire, notably India and Pakistan, which latter countries accounted for 15 per cent. of the total dues on foreign exports.

The reconstruction of war damage and the modernisation generally of their estate was proceeding apace, Mr. Gardner said, and the Waterloo River entrance, which was opened by Princess Elizabeth last March, would they were confident, prove of great benefit to the coasting trade. The great programme of new shed construction was now getting well into its stride. The sheds at West Alexandra and North 2 Canada had been completed with the exception of cranes, while early in the New Year they hoped to have the new shed at South 3 Canada in commission. A start had also been made on the four new sheds at North 3 Alexandra, North 1 Canada, North Wellington and North side, West Float. The most modern equipment, in the shape of cranes, transporters, etc., was being provided. The year too had seen the completion of the major repairs to the Gladstone-Hornby Lock and the commencement of the Canada-Langton Improvement Scheme, and the whole scheme was estimated to cost over £10,000,000. The Board are promoting a Bill in the ensuing session of Parliament to provide fresh borrowing powers and also to make the necessary adjustments in the statutory maxima or " ceilings " of their rates to allow for the present level of costs.

Finally, Mr. Gardner said, that the many uncertainties of present day trade, especially having regard to the far-reaching effects of devaluation were particularly evident to such an Authority as theirs, the whole object and being of which is wrapped up in foreign trade, and the rapidly changing conditions called for never ceasing vigilance on the part of the Board. It was to be hoped that the review of ports indicated in the Transport Act would not lead to any measures likely to reduce the local autonomy of ports which enabled them to maintain such a high state of efficiency in coping with ever changing conditions.

Port of London

The annual report of the Port of London Authority for the year to March 31 last states that the tonnage of shipping using the Port has continued to rise and for the year under review was 4½ million tons more than in the previous year and about 74 per cent. of the tonnage entering and leaving the Port in the year to March 31, 1939. The total tonnage of goods passing through the Port also shows an increase over the previous year, being about 93 per cent. of the traffic for the year 1938-39, but the constitution of the traffic continues to fluctuate widely.

Total imports show an increase over the previous year of over 860,000 tons, but certain important commodities, particularly provisions and timber, show a heavy decline which is reflected in the considerable fall in the tonnage of import goods landed or received by the Authority for warehousing or immediate delivery. The tonnage of foreign exports for the year was 31 per cent. above the 1938-39 figures. Of this traffic, the amount shipped over the Authority's quays was more than double the tonnage dealt with before 1939.

The net register tonnage of vessels that arrived and departed with cargoes and in ballast from and to British countries and foreign countires and coastwise, excluding naval vessels and vessels with naval crews requisitioned or chartered for naval or military transport service, but including vessels on Government service with mercantile crews even if engaged on operational duties, during the 12 months ended March 31, 1949, amounted to 45,939,095 tons, compared with 41,372,625 tons in 1948, and 62,085,840 tons in 1939.

The tonnage of imported and exported goods, foreign and coastwise, for the 12 months ended March 31, 1949, 1948 and 1939 respectively was as follows :

		1949 Tons	1948 Tons	1939 Tons
Imports	...	31,513,894	30,649,820	34,098,315
Exports	...	7,387,500	5,728,431	7,563,748
Total	...	38,901,394	36,378,251	41,662,063

The tonnages of goods landed or received by the Authority for warehousing or immediate delivery or for export during each of the years ended March 31, 1949, 1948 and 1939 were as follows :

			Imports Tons	Exports Tons
1949	...	...	1,790,584	1,577,049
1948	...	...	2,231,226	1,158,777
1939	...	...	2,091,032	744,625

The accounts of the Authority show that the capital expenditure for the year amounted to £160,205, the principal items being: Purchase of cranes and provision of ancillary services in connection therewith, £51,991; purchase and adaptation of river

(*concluded on page 283*)

Production and Study of Ocean Waves in the Laboratory

By F. J. SINES, M.S.C.E., Structural Designer,
Port of Seattle, Seattle, Washington.

Wind, blowing across the surface of the ocean, transfers energy to the water surface generating waves at sea. In open water, these waves build up gradually to a condition of stability which is very difficult to simulate in laboratory wave tanks. Experimentation in wave theory and model breakwater studies cannot be carried out profitably unless the employed waves uniformly duplicates the ocean waves they represent.

At the University of Washington in Seattle, a new type of wave machine produces waves which are of true form as they leave the source. By setting the machine to conform with theorectical wave properties, the height, length, and orbital particle movement are controlled.

Wind generated waves, the forces of which are applicable to breakwater design, are surprisingly similar. Enough so that they may be analysed theoretically and their properties predicted with a reasonable degree of accuracy. As with waves of sound and light, the relationship between wave length, period, and velocity is

$$T = \frac{L}{V} \qquad (1)$$

where T is the period or the time required for two successive wave crests to pass the point of the observer, L is the distance from crest to crest and V the velocity of propagation of the wave.

For small oscillations caused by slight disturbance of the water surface, the velocity of the wave form is expressed by the equation:

$$V = \sqrt{\frac{gL}{2\pi} \tanh \frac{2\pi D}{L}} \qquad (2)$$

g, being the acceleration due to gravity and D, the still-water depth.

In very deep water, $\tanh \frac{2\pi D}{L}$ approaches unity and Eq. (2) becomes

$$V = \sqrt{\frac{gL}{2\pi}} \qquad (3)$$

Although no sharp dividing line exists, the transition from deep to shallow water conditions occurs when the depth is one-half the wave length. The trochoidal theory applied to deep-water waves assumes the water particles to trace circular orbits without translation in the direction of wave travel. The orbit radii decrease rapidly below the surface, the radius at any depth (**Wave Action in Relation to Engineering Structures,** D. D. Gaillard) being

$$r = r_s \epsilon^{-\frac{d}{\frac{L}{2\pi}}} \qquad (4)$$

where r_s is the surface particle radius, ϵ the base of the natural logarithms and d, the depth below the surface.

Since one revolution of each water particle is accomplished in one wave length, the orbital velocity is

$$u = \frac{2\pi r}{T}$$

Substituting Eq. 1 for T gives

$$u = \frac{rV}{\frac{L}{2\pi}} \qquad (5)$$

Equalisation of the quantity of the water in the crest with the quantity absent from the hollow requires the orbit centres to be above their still-water positions a distance y.

Theoretically, the wave form in deep water closely resembles a trochoid curve. One remembers a trochoid as the path traced by a point somewhere between the centre and the periphery of a rolling circle. The upper limit of the trochoid is a cycloid where the surface orbital particle radius is equal to the radius of the rolling circle. Under this condition, the wave height H, is equal to twice the rolling circle radius, and a common ratio for measuring wave steepness, the $\frac{L}{H}$ ratio, is equal to π Before this limit is reached however, the wave becomes unstable and breaks. Observation has shown breaking point of the wave to be near an $\frac{L}{H}$ ration of seven. Only to this point does the trochoidal wave form exist.

The new wave machine duplicates these theoretical wave properties with a flexible stainless-steel plate perpendicular to the direction of wave travel. Assuming the same position of any water particle adjacent to it as the particle travels in its orbit, the plate imparts the desired amounts of energy to the water at various depths. The plate is actuated by synchronised adjustable arms rotating similar to the particles illustrated in Fig. 1. Setting these arms by Eq. (4) to conform to the orbit radii for their respective depths generates particle rotation, for the plate exerts on the adjacent water particles at each stage of the wave a force similar to the plane of particles it represents in the actual wave. As particle rotation is introduced at the source, the wave attains its true form as it leaves the machine.

Since the radius of the particle orbit at the surface is one-half the wave height, variable wave heights are obtained by adjusting the plate stroke at the surface. To produce any desired wave height, the plate stroke is controlled by setting the surface particle arm to one-half the required wave height and positioning the lower orbital arms by Eq. (4), since the wave height is also greatly influenced by the imparted wave energy.

The orbital velocities of the particles set forth in Eq. (5) are directly proportional to the RPM of the rotating arms of the machine. Converting to RPM and substituting Eq. (3) for the wave velocity produces the expression for the RPM in terms of the wave length:

$$RPM = \frac{60}{2\pi r}\left(\frac{rV}{\frac{L}{2\pi}}\right) = \frac{136}{\sqrt{L}} \qquad (6)$$

For any desired wave length the required RPM is determined by Eq. (6).

In operation, the new wave machine is subject to limitations arising from the deep-water trochoidal theory. The water particle orbits are circular only under deep-water conditions when the depth of water is greater than one-half the wave length. Utilisation of an existing channel four feet deep limits the wave length to seven and one-half feet for an operational still-water depth of three and three-quarters feet. If the wave is to be trochoidal in form, further restrictions arise with the wave steepness, or the $\frac{L}{H}$ ratio. Minimum value of $\frac{L}{H}$ is seven, thus the maximum wave height for a seven foot wave length is one foot.

Preparation of the existing 170-ft. channel to receive the machine required slotting the walls and floor. Sixty feet from the end, two foot square notches were constructed in the channel sides and a six inch deep slot across the bottom. The plate, four feet wide and four feet high, then covers the entire cross-sectional area of the channel; the slots accommodating the frame and external mechanism of the machine.

Observation of the first waves to emerge from the machine indicated an unfavourable condition within the side slots leading to an interference with the main wave. The difference in head on either side of the plate equal to the energy imparted to the wave resulted in a lateral motion of water in and out of the slots. This lateral displacement superimposed a secondary wave upon the main wave approximately one-quarter of a wave length aft of its crest. Reduction of this undesirable occurrence was attained by placing cut-off plates over the channel slots on each side of the main plate.

Waves produced in a closed tank are greatly affected by wave reflection. Various types of wave absorbers were considered but for economy and ease of construction a simple device was developed. Extending horizontally across the channel, two platforms, five feet long were mounted twelve and nine inches below

Production and Study of Ocean Waves in the Laboratory—continued

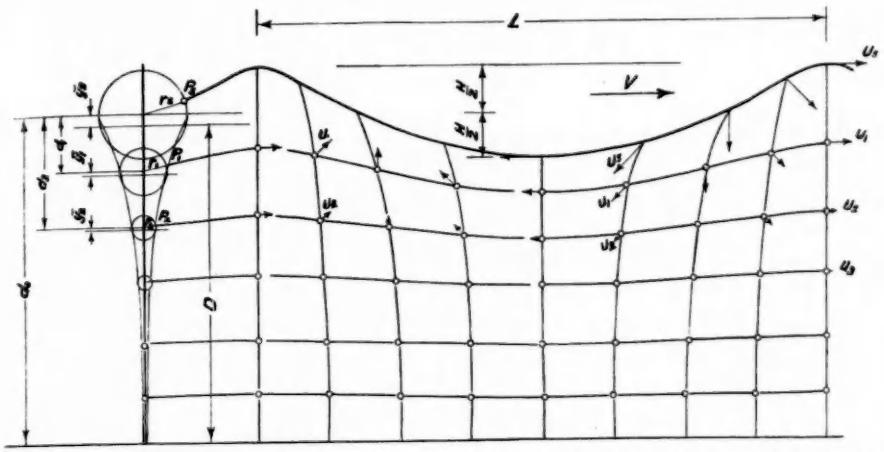


Fig. 1. The trochoidal water wave duplicated by the plate-type machine. Indicating the particle positions throughout one wave length, the grid illustrates the deformation of the plate at various stages of the wave. The arrows show the instantaneous particle velocities.

Fig. 2. The wave generator installed at the University of Washington wave tank.

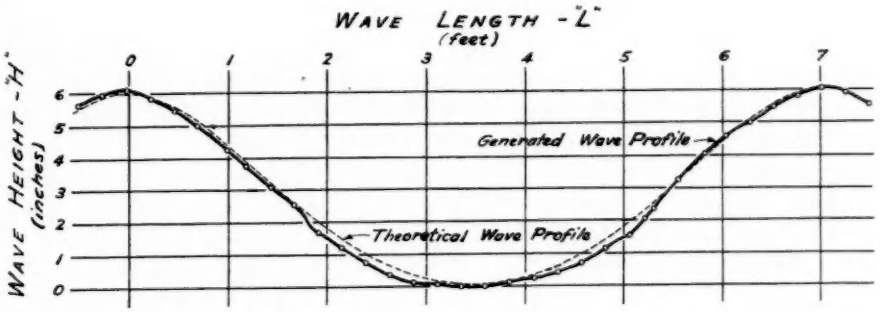


Fig. 4. Graphic comparison of the theoretical wave profile with the wave shown in Fig. 5.

Fig. 3. The concrete-cylinder wave absorber.

the water surface. On these platforms, six inch diameter, twelve inch high concrete test cylinders are placed as shown in Fig. 3. Satisfactory results were achieved, for the wave in passing through the absorber is reduced to one-sixth the height of the main wave.

With the elimination of the major interferences to the formation of the true wave, the ability of the plate-type wave machine to produce a simulated wave with properties corresponding to ocean waves can be seen. Fig. 5 pictures a mean wave for the machine, well within the operational limits imposed by the trochoidal theory. Its height is six inches and length seven feet, giving a steepness $\frac{L}{H}$, ratio of fourteen. With a still-water depth of three and three-quarters feet, the $\frac{L}{D}$ ratio is 1.87. The radius of the surface particle arm is three inches, and the settings for the lower arms are established by Eq. (4). From Eq. (6) the RPM setting of the variable speed reduction gear for a wave with these properties is 51.4.

Production of true wave form and desired wave height clearly illustrates the sensitivity in varying the energy imparted to the wave. Slight energy losses occur in the transmission from the machine to the water. Since the imparted energy is largely a function of the plate area adjacent to the water, the procedure for locating the true wave is to vary the still-water depth while recording the resulting wave photographically. For the current machine setting the true wave occurs at a still-water depth one-quarter inch above the theoretical depth.

Although the generated wave conforms quite closely to the theoretical wave properties, additional improvements are being made to increase the rigidity of the machine and to reduce farther

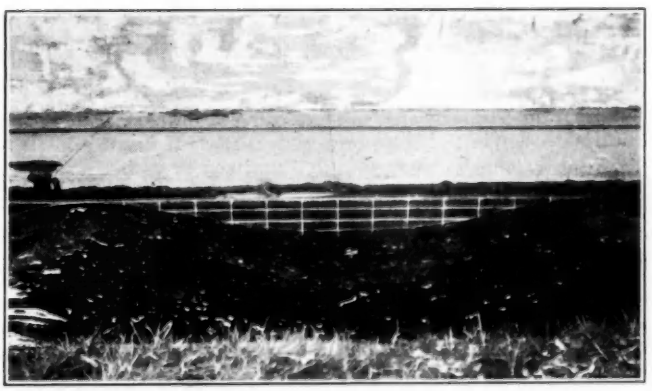


Fig. 5 A controlled wave produced by the new-type machine.

the unfavourable effects of wave reflection. Present and future studies at the University of Washington employing the plate-type wave machine include: comparing the generated deep-water wave to its theoretical properties; shallow-water waves using a sloping bottom; stability of beaches subjected to wave action; and the practicability of building deep-water breakwaters.

Prof. R. G. Hennes of the University of Washington conceived the possibility of duplicating the trochoidal theory mechanically and Prof. F. B. Farquharson, Director of the Engineering Experiment Station at the University of Washington aided materially in its construction.

The Study of the Marine Biology of Harbours

By ERIC HARDY, F.Z.S.

The growth of marine fauna and flora in harbour waters and their vicinity may influence currents in the formation of mussel beds, prevent coast erosion in the growth of mud-binding and sand-binding species of plant life, cause losses to harbour piles and woodwork by timber-boring molluscs, and have many other far-reaching effects.

The fauna and flora of the sea and estuary waters at a harbour are not by any means constant. They change seasonally and are influenced by winds, currents, pollution and salinity. The currents and the weather along the shore vary annually, as do the conditions of surf, tide and light, which play such effective parts in the distribution of marine life. Even on a rocky coast where the rocks themselves remain from year to year, the seaweed growth varies annually, because most of the seaweeds are annual plants, varying in their distribution and growth. On the west of Ireland the fronds of laver assume astonishing lengths often of several yards. This affects the flow of currents and may shield a soft coast from erosion one year or expose it another. The position is less stable on mud shores, and least of all on sandy beaches and bottoms. Only in the very deep parts (600-ft.) of the continental shelf and the ocean bed is marine life reasonably stable. Thus a study of a harbour fauna and flora made by zoology students during a short summer vacation may give a very different picture from the same area in winter after gales have torn up vast areas of weed and strewn the shore with piles of Macoma shells lifted from the local channels.

The seaweed zones are mostly along the shores, and the marine life in a harbour is mainly animal. A jetty carved in the rock would, of course, have a typical rock shore seaweed flora. The order in which marine animals colonize a new harbour structure varies both seasonally and locally and there appears to be little uniformity.

Let us consider the shipworms, which are so destructive to harbour timber unless it is in water so heavily polluted, like that of the Mersey, that the shipworms cannot live. These creatures are not worms, of course, but specially adapted molluscs which have evolved along lines of mutations to the peculiar habit they find so successful. They are relatives of the mussels and clams and have the habit of using their shells as boring organs by which the shipworm larva, free-swimming in the sea, bores into wooden pilings and wharfs after coming into contact with this timber and fastening itself to it with a sucker-like "foot". The shells are reduced to a small size only, and are at the front end of the mollusc. By a downward and inward movement the shells cut a burrow, wherein the shipworm wedges itself tightly against the walls and secretes or forces into the head end of its body some of its body fluid, to expand this and thus gain a hold while the boring proceeds.

Some timbers, especially Douglas fir and other soft woods not properly protected, may soon become thickly infested with numerous shipworms, but they all avoid cutting into each others' burrows. That is why such timbers become honeycombed with burrows and when put to any strain suddenly collapse. The two most common kinds of shipworms, *Teredo* and *Bankia*, make burrows up to 6 inches and 3 feet long respectively at the rate of three-quarters of an inch a day.

There are several other boring molluscs, mostly in mud and soft stone, and the boring sponge *Cliona celata* is a very common inhabitant of British waters. This sponge has two forms, the large yellow cheesy mass on sandy shores which is often found near Liverpool, and the smaller form which tunnels a network of galleries in limestone and limestone-built harbour structures, such as Plymouth breakwater, thus helping their destruction. It is also encouraged by the presence of oyster-shells, in which it bores.

In his recent book on "The Natural History of Marine Animals," Professor G. E. MacGinitie describes an equally interesting Californian sub-species of this same boring sponge that troubles Plymouth breakwater. He has noticed it bores into shells to increase its powers of holding on to some object, the sponge being more or less encrusted over the surface of the shell and attached by tiny holes it has dissolved into the shell. There he has also found it in barnacle "shells," clams and oysters ("abalones"). Shells bored by these sponges are often picked up on our own coasts and appear to be punctured like a pepper-pot. Another boring sponge ("*Viola*") occurs on the limestone Mediterranean coast at Beirut harbour.

Barnacles are another source of study, largely to produce metal plates that resist the young barnacle's persistence to fix itself —plates with a poisonous paint not easily leached by the sea, or a very highly polished, hard chromium surface upon which a footing is difficult. Although we talk of barnacles' "shells," they are not true shellfish like the shipworm, but members of the crustaceans, the animal tribe to which crabs, lobsters and shrimps belong and, of course, many lesser little-known marine creatures of great economic importance. The barnacle hatches free-swimming and after several moults fixes itself by its antennules to a rock, a buoy, a ship's bottom or some other surface for its permanent adult habitat. Here it pupates and finally completes the metamorphosis into the adult barnacle, which secretes around itself the hard plates of calcium carbonate we call its shell. From the shape of these shells some of the common barnacles are called acorn barnacles. They have six pieces to the shell. Others with a long leathery "stalk" are called goose-necked barnacles. Their shells usually have five plates. The barnacle feeds from the sea (not like the shipworm from the timber) by extruding its feet through the opening or operculum to its shell, and kicking in minute food from the water. Thus the animals survive low tide by merely closing the operculum and, unlike the shipworm, they find life tolerable in the 45,000,000 daily gallons of crude sewage washing up and down the Mersey estuary tides. They feed upon minute plankton and estuary detritus.

A special chapter will be found devoted to barnacles and molluscs in Professor C. M. Yonge's new book on "The Sea Shore," a work devoted mainly to the 600,000 acres of shore around the British Isles, and though more elaborately illustrated than MacGinitie's work, probably not quite so exhaustive.*

Barnacles grow in zones in relation to the tide, and different species can be mapped out in the tidal zones. When barnacles are densely overcrowded, as on the bottoms of ships, they elongate their shells; but the gooseneck barnacle, which sometimes grows in mussel beds, can hang in a cluster from a natural float on the surface of the sea. Various species of acorn barnacles will grow on the bodies of large fish like cod, swordfish and shark, or on whales; but there are also some shell-less forms (like *Conchoderma*) which attach themselves to marine animals.

It is not always appreciated by the sufferers from barnacle growths that some of the predatory enemies of the economic shellfisheries of a harbour render some useful service in keeping down the barnacle growths. These include starfish, whelks or buckies, and some of the parasitic worms. There are also many barnacles, including small parasitic forms, that are of no influence upon harbour installations at all. On the sandy coast of Palestine, two species of barnacle were commonly washed ashore adhering to driftwood.

There, on the lime cliffs of the warm Lebanon coast near Beirut, boring molluscs are very common, notably *Pholas candida* (rough shell), *Lithodomus, lithophagus* (smooth shell) and *Venerupis irus*. Most of the boring shellfish tunnel into stiff clay banks without any serious harm.

The study of marine biology at the harbour is not entirely one of curbing the activities of borers in wood and rock, or protecting piers from destruction and ships and channels from fouling. There is an inter-dependence of marine life which has to be appreciated, and there are factors like food, growth and life history, all of which may have significant results. Debris and sewage create an important amount of food for marine life, both animal and vegetable, and as the bacteria in sea-water finally break down the sewage and purifies the water again, they provide rich feeding for

* Some other useful introductory books are Flatteley and Watton's "Biology of the Seashore" (Sigwick and Jackson, 1922), and Newbigin's "Life on the Seashore" (Allen and Unwin, 1931).

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the algæ and so extend the growth of the seaweed beds. In periods of great heat-waves or severe winter frosts like early 1947, low tide exposes vast numbers of small shellfish, young inshore fishes and other marine life to death from these abnormal conditions. The shore may become littered with an offensive nuisance in the form of dead and decaying animal life. In these cases a large local population of seagulls and crabs is advantageous to act as scavengers. It is the sudden changes in temperature which affect these widespread destructions of life at the tidal zone. A sudden rise of temperature from 50 to 80 degrees will kill life that could well tolerate the 80 degrees if the rise were slow enough for its body temperature to keep pace with it. It is true that where the seashore is used for bathing, the saline sea is a natural sterilizing agent for disease-producing pathogenic bacteria. But that does not mean that sewage can be tipped into the sea with impunity. It has been shown by Clifton, with Dublin sewage and elsewhere, that solids should not be deposited in the sea, otherwise *B.coli* from human sewage will not only drift to bathing beaches if currents and tides are disregarded, but be blown back ashore, or to promenades, with the sea breezes.

Most harbours are sited at estuaries and here there is the very interesting effect of freshwater brought down by the rivers, and which usually floats for some distances† and spreads over the surface of the sea. Moreover the fauna of shells, crabs and the attendant predatory fish is usually greater off an estuary than further along the coast, where the salt water is less diluted with fresh.

One effect of heavy surf beating upon piers, rocks and piles, is that they will have less marine growth growing upon them than similar structures in calmer water. On a sandy beach the surf will, of course, alter the beach itself and also restrict the fauna mainly to a burrowing one. If, however, a rocky shore has a good seaweed flora, this will break the effect of the surf, as may be seen on the Channel Islands coast around St. Helier on Jersey, and St. Peter Port on Guernsey. Mussels, oysters and other shell fish communities growing in the same place year by year build up their shell beds to keep pace with the deposit of mud. Thus they may in time greatly check the force of surf and local currents. But it takes many years to effect such changes and in a mussel bed the effect may have considerable engineering significance when the mussels have grown so big and hard in the shell that the fishermen do not gather them for sale, the parasitic borers find the shells too tough to penetrate, and the mussel-eating sea-duck which come to the harbour in winter cannot eat such big shells.

It will be appreciated from the foregoing that a distinct difference lies in the fauna of a sandy shore like that around Liverpool or Preston, compared with that of a rocky region like the vicinity of Plymouth or Jersey. Rocky shores are generally more exposed to rough seas, but in their numerous pools and crevices they support the larger variety of life. But again, rocky shores vary one from another, according to the steepness or shallowness of the slope; but they are much more stable in structure than sandy ones. The mud and sand banks of an estuary can generally be divided into stable or permanent banks and unstable or shifting banks which alter shape according to the currents. It will be found that by far the greater marine fauna inhabits the stable banks, and the unstable banks may often be without anything. Mud banks not only afford harbourage to mussels but in summer encourage, when exposed at low tide, a felt-like growth of algae or green slime plants. The mud is also a great haunt of nematode or thread-worm burrows, predators which do not live in a permanent burrow like the molluscs, but roam about in search of their prey. Even the octopus will sometimes make burrows or retreats in mussel beds.

On the Palestine coast we can now see two very interesting examples of these differences side by side in two ports which are being enlarged and developed by the new State of Israel—the rocky port of Jaffa, formerly Arab but now an administrative suburb of the adjoining lighterage port on the sandy shore of Tel Aviv. Work is shortly to begin to make Tel Aviv a deep sea port on plans completed early this year by American dock experts invited there by the Municipality. From Gibraltar a general current passes along the Mediterranean along the North African coast to Palestine at an average speed of one mile an hour, sometimes increasing to 2 or 3 m.p.h. or dropping to zero, and there are occasionally counter-currents. The temperature —always in relation to the depth of water—is about 4 deg. higher in this eastern part than in the west, and this has an important bearing upon the marine fauna. This temperature will vary between 15 and 30 deg. C., according to that of the air. Even here on the Palestine coast the freshwater of the Nile estuary slightly influences the fauna. It affects mainly the salinity. It is in September/October that this freshwater invasion from the Nile brings down the salinity of the sea around Tel-Aviv and Haifa ports, and greatly increases the phyto-plankton or algæ growth.

Of this shore, where rock gives a solid footing, large banks are sometimes formed by the formation of large blocks or cemented shells of cases by the worm-snail *Vermetus*. Related species of this tubed mollusc inhabit both American coasts, one of which, *Aletes*, on the Pacific coast, cements its shell to rock and then grows out a feeding tube. Great clusters sometimes form at a fast rate and they will grow on pilings.

Ever since the Victorian "giant" of marine biology, Sir William Herdman, laid the foundations of modern scientific study of the life in the sea, there has been a steady appreciation of its economic importance not only to the fisheries, but to harbours, ports and all who come into contact with the sea, including engineers.

† The Nile is traceable 300 miles out in the Mediterranean.

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craft, £39,088; construction of new quay sheds, etc., North Side, Royal Victoria Dock, £28,751. In addition, an amount of £410,507 was expended on the repair and reinstatement of war damage.

The year's working resulted in a total reveune of £10,317,333 (£10,290,902 in the previous year) and a total expenditure of £7,446,515 (£6,862,947), leaving a balance of revenue of £2,870,818 (£3,427,955). After charging interest on Port Stock, Stock (Redemption) Fund charges, income tax, etc., there was a surplus of £433,975 for the year. Set off against the deficit balance brought forward of £5,190 there remains a surplus of £428,785 to be carried forward.

During the year 1,309,107 cubic yards of material were dredged from the river and 1,678,041 cubic yards from the docks. The Admiralty have continued to act as contractors to the Authority in suitable instances for the purpose of clearing by dispersal methods wartime wrecks in the lower reaches.

The survey and charting of the river has been facilitated by the installation of modern echo-sounding machines in the survey launches, one of which is also fitted with "Decca" navigator. It was decided to take advantage of the public radio telephone service to be provided by the General Post Office in the Thames Estuary and several of the Authority's river craft are being fitted for this purpose.

Retirement of Notable Port Officials

Mr. L. Leighton, Engineer in Chief at the Port of Liverpool, has retired after 35 years' service with the Mersey Docks and Harbour Board. Since the war he has been responsible for the design and execution of the schemes for the rehabilitation of the war-damaged Mersey docks system.

Mr. L. Boogerd, Managing Director of the Port of Amsterdam and Schiphol airport retired last month after more than 32 years in the municipal service. Under his management important improvements and extensions of the port and its connections have been brought about. He entered the service of the port authority as an engineer in 1917, and was promoted chief engineer in 1924, being subsequently appointed Managing Director in 1930.

Notes of the Month

Port of Varna to be Renamed.

Sofia newspapers have reported that the Bulgarian Black Sea-port of Varna is to be renamed Stalin. The papers said the decision was reached at mass meetings of Varna workers, attended by Communist Party representatives and members of the City Council.

New Pier for the Port of Houston.

The Commission of the Port of Houston recently asked for tenders for the construction of a new 500-foot open wharf which is expected to cost more than $1,000,000. The wharf will be sixty feet wide and equipped with rail and truck facilities.

It is to be known as Wharf 16 and will be located east of the Turning Basin, and will handle lumber, pipe and other materials which do not require shed coverage. The tenders will be based on three different tyes of construction. The wharf is part of the current $9,000,000 improvement programme which is at present in hand.

Development of the Port of Auckland.

The reclamation of at least 900 acres of land from the Upper Harbour to facilitate the proposed extension of the Port of Auckland, N.Z., may be undertaken by overseas contractors. The Chairman of the Harbour Board announced recently that the Board's Engineer, Mr. N. L. Vickerman, now on an overseas tour, had been instructed to see if contractors from any part of the Empire or from Holland would be interested in the scheme, as the Board's plant is not adequate for such a major task. Preparations for the development of the port between Point Chevalier and Te Atatu have been given an impetus by the passage through the House of Representatives of the Auckland Harbour Development Bill vesting 6,900 acres of the harbour bed in the Board.

Panama Canal Locks to be Overhauled.

It has been announced that the Pacific locks of the Panama Canal will undergo a periodic overhaul for approximately three months commencing on January 7. The authorities do not anticipate this will cause traffic delays except possibly of a few hours when traffic is unusually heavy.

Facilities to be Improved at Port of Wellington.

The Wellington Harbour Board has decided to spend £500,000 in the next three years on the improvement of wharf equipment at Aotea Quay. The improvement plans will include new sheds, coal-handling equipment, roads, fences and gates. The Board will later consider a scheme for a new wharf at Aotea Quay which will be capable of accommodating one ocean-going vessel and a coaster on each side. It is estimated that the new wharf may cost £1,000,000.

Improvements at the Port of Mobile.

After two and a half years work, the Alabama state docks at Mobile are now ready for service. The first pier and warehouse have just been completed, and two other piers and warehouses will be put into commission later, increasing the berthing capacity of the terminals to 25 ships. About $4,250,000 has been spent on the project and the city of Mobile contributed waterfront property to the value of about $1,000,000.

New York Pier Leased to French Line.

It has been officially announced in New York that a 10-year lease of Pier 88, North River, New York, has been signed by M. Guy de Berc, local general manager of the French Line. The basic rent is $269,534 a year, but the line has the option of renewing the lease for a further 10 years at a rental of $296,487, an increase of 10 per cent. The agreement is subject to the final approval of the New York City Council.

TENDERS.

TO CIVIL ENGINEERING CONTRACTORS—TENDERS INVITED.
DUBLIN PORT & DOCKS BOARD.
GRAVING DOCK AT DUBLIN.

Tenders are invited from Civil Engineering Contractors for the construction of a Graving Dock at Alexandra Basin, Dublin.

The work will comprise a mass concrete Graving Dock 646 feet x 95 feet x 33 feet cope to floor; a reinforced concrete Jetty 443 feet x 39 feet; the supply and installation of equipment and the execution of all ancillary works in accordance with Drawings and contract documents prepared by Mr. Nicholas O'Dwyer, B.E., M.Inst.C.E.I., Consulting Engineer, 6, Burlington Road, Dublin.

Copies of drawings and contract documents may be obtained from the Consulting Engineer on payment of a deposit of 25 guineas (returnable to bona fide tenderers whose tenders are not subsequently withdrawn and who have returned the documents).

Sealed tenders on the form provided endorsed "Tender for Graving Dock" and accompanied by a Bill of Quantities priced and extended in ink should be delivered to the undersigned not later than the 27th day of June, 1950.

The Board will not be bound to accept the lowest or any Tender, nor will any Tender be paid for.

By Order,
R. F. LOWE,
Secretary.

Dublin Port & Docks Board,
19/21, Westmoreland Street,
Dublin.
12th December, 1949.

BOROUGH OF BANGOR.
CRANE REQUIRED.

The Bangor Borough Council invite tenders for the supply and erection on site in working order of a travelling jib crane operated by electricity, diesel fuel oil or steam.

The crane is to be capable of hoisting, slewing and level luffing and of discharging small or large coal by grab at upwards of 80 tons per hour. It is also to be capable of discharging general cargo, coal by bucket, and of sand grabbing.

Further particulars may be obtained on application to the undersigned.

Tenders in sealed envelope, endorsed "Tender for Crane," must be lodged with me by Twelve noon on Wednesday, 1st March, 1950.

The Council do not bind themselves to accept the lowest or any Tender.

R. M. MOORE,
Town Clerk.

Town Hall, Bangor, Co. Down.
6th December, 1949.

PUBLIC APPOINTMENT.

THE COMMISSIONERS FOR THE PORT OF CHITTAGONG.

Applications are invited for the post of Assistant Harbour Master in the grade Rs. 750-25-1,000 E.B.-50-1,150 p.m. plus Rs. 150/- per month as Overseas pay for non-Asiatics where applicable plus a dearness allowance depending on the cost of living, at present at 20% of basic pay plus rent-free quarters subject to such revision as may be introduced by Pakistan Pay Commission. Applicants, who must not be more than 30 years of age, must hold Certificates of Competency as Foreign-going Master recognisable under the Indian Merchant Shipping Act, 1923. Applications should include particulars of education, record of sea service, copies of testimonials (conduct, sobriety, ability) and record of any previous service as Pilot or Harbour Master. Leave in accordance with Fundamental Rules of Government of Pakistan. Membership of the Commissioners' Contributory Provident Fund is compulsory. The successful candidate will be on six months' probation on Rs. 600/- p.m., after which he will be required to sit for examination for a second grade Pilot's licence as the duties include piloting and berthing ships.

Applications should be submitted in writing to Messrs. Rendel, Palmer & Tritton, 125, Victoria Street, London, S.W.1, in the first instance, and will be received up to three weeks from the date of the advertisement.

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Steel Screw Steam Tug "HARBOURWORKS 20"

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Triple expansion coal fired 250/300 H.P.

Inspectable near Morecambe.

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